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Cover picture: *Zapotec Indians in the village of Talea, in the Oaxaca mountains, Mexico, discuss the price of chilli. The mark on the wall, CNEP 322, is that of the Government anti-malaria service and shows that the building has been sprayed with insecticide.*
Photo: *Joan Rodker*

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EFTA

divided

by **G. L. Tedder,** *Shell International Chemical Company.*

In this article the author examines future plans for European agriculture in the light of the formation of the European Economic Community and the European Free Trade Association. He shows that some forms of protection and price support for agriculture are essential, since there exist enormous political difficulties to be overcome before changes can be made in the way of life of millions of small and peasant farmers. Whereas in the case of industrial products it is possible to talk in terms of free trade, in the case of agricultural products the author suggests that it would perhaps be better to talk of fair trade.

The last two or three years have seen the signing of two multi-lateral treaties in Western Europe, both designed to bring about a liberalisation of trade between their signatories. The first, in order of creation and importance, was the Treaty of Rome, 1957, which established the European Economic Community (EEC)—also known as the 'Six'. The members of the EEC are Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands. The treaty also includes, as 'Associated Territories', many of the dependent territories of the Six which will both enjoy duty-free access to the Common Market set up by the treaty, and will also receive large official investment from the six countries. The formation of this Common Market, which is a major aim of the EEC, is to be brought about by the reduction and eventual elimination of tariffs between members and the harmonisation of external tariffs, so as to arrive ultimately at a common external tariff for each commodity or class of commodity.

The second treaty was the Stockholm Treaty between Austria, Denmark, Norway, Portugal, Sweden, Switzerland, and the United Kingdom—known as the 'Seven'—signed in October, 1959. Here again the objective behind the European Free Trade Association (EFTA) which the treaty brought into being was the liberalisation of trade between members. Unlike the EEC, however, external tariffs were not to be harmonised and each member country was to maintain its own tariff and trade policy to non-member countries.

Negotiations for a wider free trade area had been going on for a number of years before the formation of the EFTA, in the hope that some form of bridge could be formed between the Six and other European countries. These negotiations failed for a number of reasons: one was the fundamental difference in outlook between the United Kingdom and France on the question of agricultural policy; another, less obvious but equally important, was the closeness of the union between the Six, which implied a limitation of national sovereignty that the United Kingdom, in view of its wider political obligations, felt unable to accept.

The Need for Coordination

At the present time agriculture is protected in various ways on a national level, the most common method being protective duties and subsidies. The reasons for such protection have, however, in most European countries undergone changes in the last 15 years. Immediately after the last war there was the necessity of stimulating production and checking rising food prices. With the improvements in world food supplies the emphasis changed to one of encouragement for specific commodities in order to conserve foreign exchange and improve the balance of payments. With the upturn in industrial expansion, however, the gap between industrial and agricultural incomes widened and government policy was directed towards the narrowing of this gap.

Nearly all countries have schemes for preventing agricultural prices from falling below a minimum remunerative level. Import duties and quotas can be used to create an internal price above that obtaining in the world as a whole;

an export subsidy enables surpluses which would otherwise lead to a depression of domestic prices to be disposed of outside. Marketing boards can be used to maintain prices and avoid surpluses (but only at government expense, by a guaranteed price or a restriction in production by acreage control or marketing quotas).

Assistance to small farmers is the latest direction which policy on the support of farm prices is taking. This is in order to limit the variations which exist in each country in the costs of production and profitability of farming. Thus there are now schemes for farm improvement and subsidies for the consolation of uneconomic holdings.

Having recognised the need for protection on a number of grounds it is now necessary to point out that while nearly all methods are on the surface matters of domestic concern, they in fact have a much wider effect. Putting aside the obvious 'aid to export' of export subsidies, any stimulus to production is bound to have a similar effect on international trade in the commodity whose production has been stimulated. It therefore follows that undertakings not to dump or to refrain from imposing import restrictions do not go far enough. Before European prices can be adjusted so as to bring a fair return for the producer without the necessity of upsetting other markets, there must be coordination of agricultural policy in the widest sense.

Achieving Coordination

In order to achieve coordination of agricultural policy it is not sufficient to sign broad treaties like the Rome and Stockholm treaties, covering all products. Within the framework of these treaties there must be institutions directed towards a common policy for agricultural products.

Various plans have been produced containing proposals for a regulated market in agricultural products. As early as 1950 an Agricultural Community on the lines of the European Coal and Steel Community was proposed by Dr. Mansholt.* Under his plan there was to be the fixing of stable prices for intra-European trade, control and eventual elimination of national protection, and, in the meantime national prices to vary according to the degree of protection in force.

In 1951 was put forward the Charpentier Plan* which proposed a similar High Authority that would have the the power to impose levies for the maintenance of a European price. At a later stage countries would be directed towards forms of production for which they were best fitted. A development from this was the Pflimlin Plan*, which propounded the early creation of a common market in key products of which the most important would be wheat.

When the question came to be examined by an interim committee of OEEC, wide differences in attitude became apparent. Either steps could be taken to liberalise trade, which would in turn lead to the encouragement of more economic producers and force amalgamation and rationalisation, or various forms of planning and control could be imposed which would stabilise the position and guarantee an adequate income to the European producer.

*See Glossary.

Unfortunately the gulf between these two attitudes proved so deep as to become one of the major stumbling blocks to the creation of a larger free trade area; this was the difference in the policy between the United Kingdom and France which has already been alluded to.

Under the Stockholm treaty agricultural policy was to be settled by a number of bilateral agreements and this *ad hoc* approach has already led to a marked liberalisation of trade between the United Kingdom and Denmark, who are the most important trading partners in the agricultural sector so far as the EFTA is concerned.

The proposals for the EEC are much more complex but are based upon certain basic principles. The most important of these is the recognition[1] that because of production conditions and the characteristics of farming units within the Community, the prices of agricultural goods within the Community cannot generally be at the same level as those obtaining in the world market; and that therefore European prices must be stabilised at a higher level. Secondly, the Commission felt that in order to avoid, as far as possible, disparity between the industrial and agricultural sectors, it would be necessary to speed up the establishment of the Common Market in agricultural products.

The Commission has proposed that joint marketing organisations should be established for most commodities, and that a single market should be created in which trade would be similar to that existing hitherto in a national market. The establishment of the agricultural community would be financed through several funds, some to be raised by direct subscription from participating governments, others to be supported by levies charged on imports into the Common Market.

It seems certain that for cereals and roots prices will be fixed in some form but for fruit and vegetables there may well be a free market within the Community, and protection will be confined to measures at the frontier.

European marketing bureaux are proposed for wheat, coarse grains, sugar and milk products, while for other commodites there will be coordination of national bodies.

The European Producer

What is the position of the European producer under these new arrangements? What benefits is he likely to gain? And what changes will there be in the pattern of agricultural production?

It can be argued that the implementation of the Rome treaty will stimulate production to take advantage of the enlarged market and the greater possibilities of specialisation. In addition, the demand for agricultural produce is likely to rise as a result of the increase in income which is expected to follow the establishment of the Common Market.

There are strong arguments for fully exploiting specialisation so that high cost production in uneconomic areas

[1]By the permanent commission set up to administer the working of the Community.

would disappear. Italy would show the most marked changes with the integration of European agriculture: here grain production would largely disappear, to be replaced by imports from France and overseas, while production of fruit and vegetables, and possibly tobacco, could be expanded rapidly. In the Dutch dairy industry can be seen an example of specialisation that has already taken place, and it might well be that the traditional trade with the United Kingdom in these products would be diverted to Germany to replace that country's imports from Denmark.

What is not certain is whether the institutions (e.g., the European Economic Commission, European marketing bureaux, etc.) envisaged will be able to achieve the full integration of European agriculture in view of the degree of supra-national control required. It is perhaps significant that the Rome treaty is a much weaker document than the treaty which brought the Coal and Steel Community into being, and that therefore the powers of the Commission may be insufficient to impose a really coherent plan on European agriculture as a whole.

There are at present four non-Communist European countries which are members of neither the Six nor the Seven. Two of these, Greece and Turkey, have important agricultural surpluses, and negotiations are under way for the association of these countries with the EEC. It is probable that Spain also will accede the Rome treaty at a later date. The position of Finland is more difficult in view of her treaty relationship with Russia, but discussions are in progress on the possibility of Finland becoming a member of EFTA.

There seems little doubt that at some point there will have to be a rapprochement between the Six and the Seven. Without going into any detail there springs to mind the difficult position of Denmark, who traditionally is a supplier to members of both groups. At the moment the full effects of the implementation of the Rome treaty are masked by the long-term contracts for the supply of agricultural products which Denmark has concluded with West Germany. But because these will limit the advantages which should accrue to Holland as a result of her membership of EEC, there have been strong protests at such actions. Because of the recent agreement between the United Kingdom and Denmark, Danish goods have tended to advance at the expense of Dutch. Many such stresses will become apparent in the next few years which will only be overcome by some measure of agreement which embraces not only the EEC, Denmark and the United Kingdom, but all European countries.

It looks, in fact, as though the immediate effects of the Rome and Stockholm treaties upon the European producer will be comparatively small, but as institutions become established and the necessary funds are made available, the present trends will become more defined and the process of specialisation accelerated.

GLOSSARY

EEC
European Economic Community, created by the Rome Treaty, 1957. Members: Belgium, France, West Germany, Italy, Luxembourg and the Netherlands.

EFTA
European Free Trade Association, created by the Stockholm Treaty, 1959. Members: Austria, Denmark, Norway, Portugal, Sweden, Switzerland and the United Kingdom.

The 'Six'
European Economic Community.

The 'Seven'
European Free Trade Association.

CM
Common Market, to be formed by the EEC for the progressive reduction and eventual elimination of tariffs between member countries, and the equalisation of external tariffs so as to arrive at a common external tariff for the Community as a whole.

Free Trade
As far as EFTA is concerned, free trade implies the progressive reduction and eventual elimination of tariffs between member countries, but maintenance of individual national tariffs for imports from countries outside the Association.

Dr. Mansholt
Former Nederlands Minister of Agriculture. Now Vice-Chairman of the European Economic Commission, set up under the Rome Treaty to organise the Community, and a specialist in the problems of European agriculture.

Charpentier Plan
M. Charpentier, the French delegate to the Council of Europe, early in 1951 submitted a plan to a special Council commission on agriculture.

Pflimlin Plan
This plan was originally drafted in the form of a memorandum presented by the French Government (in which M. Pflimlin was Minister of Agriculture) to other West European countries, in March, 1951.

Better Varieties—Better Seed

by **J. J. de Jong,** *Food and Agriculture Organisation.*

During the last 50 years, scientific plant breeding has proved to be of paramount importance in the development of agriculture all over the world. Farmers have become more and more aware that all their efforts in applying improved cultivation methods and techniques will be in vain if the variety they are growing is low-yielding or poor in other aspects. These hard facts have long been realised, particularly for cereals harvested for direct sale, since there the farmer can easily see that varieties differ in yield and quality.

Heavy dressings of fertilisers are of no use if the straw of the variety is too weak to support the heavier yield, for bad lodging will result. If the variety is susceptible to disease, the yield may be completely ruined by a severe attack, in spite of the best growing conditions. Therefore, good varieties are indispensable—not only to make full use of good conditions, but also to stand up to bad ones.

In spite of the outstanding results obtained in plant breeding work in the past, there is an ever-increasing demand for improved varieties of all kinds of crops. Also, in cereals there is a continuous need for new varieties which have higher yielding capacity, better quality and more resistance against pests or diseases, or which are superior in other characteristics important to the farmer or the consumer. Only through the application of modern plant breeding techniques will it be possible to meet this challenge.

The most rapid and effective way of making the results and progress of plant breeding work available in practice is the widespread use of high quality seed of improved varieties. FAO has recently selected this topic for concerted action in all its Member Countries in order to increase and improve food production. This is very urgent in the greater part of the world, since hundreds of millions of people are still hungry and under-fed throughout their lives, and the attainment of reasonable levels of nutrition for the entire world still seems to be a distant, if not a receding, prospect. This problem becomes even more urgent when one realises that the world population is growing at the rate of about 50 million people a year, and is expected to be doubled by the end of this century.

In comparison with other improved agricultural practices, better seed is cheap, it can be supplied easily and it can give quick results. Moreover, better seed does not call for radical changes of local crop production systems. The ultimate objective of the FAO World Seed Campaign is, therefore, to bring to the attention of agricultural producers throughout the world the value of high-quality seed of outstanding crop and tree varieties, and to promote its extensive use by education, demonstration, publicity and all other possible means. These activities are expected to reach their culmination in 1961, which has now been formally designated as the 'World Seed Year'.

The response to this campaign has so far been most encouraging, but still a great deal has to be done to make it a complete success. It is obvious that substantial progress can be achieved only by continuous effort and close cooperation between all interested parties, at both national and international levels. It is clear that the role of the plant breeder in this campaign is of paramount importance, for only through his endeavours can the farmer be supplied with the high-quality seed of improved varieties essential to ensure increased food production in all parts of the world.

The two articles which follow show what is being done in the breeding of improved varieties of wheat, barley and oats in Britain, and of maize in the United States.

Cereal Breeding in Britain

by **F. G. H. Lupton,** *Plant Breeding Institute, Cambridge.*

The three cereal crops cultivated in Britain, wheat, barley and oats, are self pollinating annuals. For this reason the techniques used by the plant breeder in handling them are similar and may be considered together. Because of their self pollinating habit, varieties of the cereal crops as cultivated today consist of more or less homogeneous populations with little variability apart from occasional mutant forms. This has not always been the case, and many of the early improvements in crop varieties arose from the selection of desirable plants from the mixed populations formerly in general cultivation. Such improvement is no longer possible, however, and the modern plant breeder must create his mixed population if he is to effect any further advances.

Two principal methods of creating such a mixed population are available. First, the breeder may induce mutations in an existing variety by exposing plants or seeds to a suitable mutagenic source. The possibilities of inducing mutations by X-rays have been known for many years, and more recently use has also been made of fast and slow neutrons, of X-rays from a suitable radioactive source and of various chemical mutagens. It must be pointed out, however, that the mutations which may be produced by such treatments do not include many of agricultural value, so that very large numbers of plants must be handled if any useful results are to be obtained.

The second method by which the breeder may create a mixed population within which to select is by the hybridisation of suitable parents. In certain cases, as when breeding for disease resistance, the choice of parents may be clear. When breeding for other characters, such as improvement in yield or grain quality, however, it may be difficult to know which parental combinations are most likely to give rise to the desired product, and it is often necessary to follow the behaviour in early generations of a number of crosses in order to choose that on which to concentrate attention.

Selection by Pedigree

When he has created his mixed population, whether by hybridisation or by the induction of mutations, the breeder must select the most desirable plants from the range available to him. The means by which this is done largely depends on the objectives of the breeding programme. Most methods of selection are based on the pedigree system, a system in which the most desirable plants are selected by eye from the second generation population. (No selection is possible in the first generation since all plants at this stage will be genetically identical.) The better second generation plants are each sown to form short rows in the third generation, and the best of these rows provide seed to sow groups of rows in the fourth generation. This process may be repeated for as many as six generations until plants from related groups are sufficiently similar to one another to form the nucleus of a new variety, which can be put into yield trials.

Various modifications of this system have been developed; yield trials, for example, may be introduced at an early stage before any high degree of genetic uniformity has been attained. Alternatively, the hybrid population may be carried forward as a bulk for a number of years before any selection is attempted. Nevertheless, the pedigree system remains the basis on which selection will at some stage be carried out.

Backcrossing

An exceptional case arises when it is desired to introduce a single simply inherited character, such as disease resistance, into an otherwise desirable variety. Under these circumstances, a backcrossing programme may be undertaken: in this case, plants of the first generation hybrid between the susceptible and resistant parent are crossed back to

the susceptible parent, and the progeny of this 'backcross' is tested for disease resistance. Provided resistance is genetically dominant, it should be shown by half of the progeny, and these resistant plants are again crossed back to the susceptible parent. This process is repeated five or six times until resistant plants are obtained which are in other respects equivalent to the susceptible parent. A similar but more tedious system is used under the somewhat infrequent circumstance where disease resistance is not genetically dominant.

WHEAT BREEDING

Two major changes in the pattern of wheat cultivation in Britain have been brought about in recent years through the activities of the plant breeder. Both these changes have taken place as a result of breeding work in other countries, with the result that wheat cultivation in Britain is at present largely dominated by varieties introduced from abroad. The introduction of a wide choice of high yielding short strawed winter wheats from North-West Europe in the late 1940s has resulted in a marked increase in yielding capacity. At the same time the production of acceptable spring wheat varieties has established spring wheat cultivation as an important component of British agriculture.

Yield and Quality

These changes have coincided with the reintroduction of a free market for cereals in Britain, which has led to a demand by farmers for high yielding varieties capable of benefiting from the application of ever-increasing dressings of nitrogen. This demand has been accompanied by an almost total disregard for the processing value of the grain produced. The climatic conditions of Britain are suitable for growing high yielding winter wheats with flour suitable for biscuit manufacturers, however, and the production of such varieties is an important objective for the plant breeder.

The combination of high yielding capacity with flour of good bread baking quality is unfortunately difficult to obtain in winter wheat, though this is an important breeding objective, since it is clearly desirable that the maximum proportion of home grown wheat should be used in the grists of the baking industry. The introduction of improved methods of selection has led to considerable progress in the breeding of high yielding bread wheats in recent years, and it is likely that varieties showing this combination of characters will shortly be available. Milling quality of the grain is inherited independently of the processing quality of the flour, and there is no reason why new varieties should not also have grain of the best milling quality.

Spring Varieties

As a result of the shorter growing season and lower yielding capacity, the breeding of acceptable spring wheat varieties suitable for bread baking appears to be less difficult than in the case of the winter wheats and several such varieties are widely cultivated. There are also several spring wheat varieties with excellent biscuit flour, though the correlation of high yielding capacity with flour of this type is not so clear as in the case of the winter wheats.

Straw

Length and strength of straw are characters which the breeder must consider in his selection programme. In the first years of the combine harvester, it was considered essential that the crop should stand up under all weathers, so that shortness of straw was an essential feature; but this situation has somewhat altered with the pick-up reel, and the modern demand is for taller varieties, with more straw for bedding or potato clamps.

Disease Resistance

Disease resistance does not limit the productivity of the wheat crop in Britain in the way that it is limited in other parts of the world. Resistance to disease is an important breeding character, however, and much of the advance in yielding capacity which has been achieved in recent years may be attributed to the improved disease resistance of modern varieties. This is indicated by the serious losses caused by the appearance of new races of yellow rust, unknown when the varieties then current were being developed, on two occasions during the past 10 years.

Besides yellow rust, the most serious diseases attacking the wheat crop in Britain are eyespot, take-all and powdery mildew, and it is perhaps no coincidence that well over half the acreage of winter wheat in this country is sown to Cappelle Desprez, a variety which shows a high level of resistance to eyespot. Sources of resistance to eyespot are limited, however, so that it may be some time before many varieties showing resistance to this disease become available.

No varietal resistance to take-all is known; a search for a suitable source of resistance is being made, though this disease can be effectively controlled by a suitable rotational practice. Powdery mildew of wheat has been neglected until recent years, although it is undoubtedly a serious cause of loss in yield, particularly in spring sown crops. An intensive programme to introduce resistance to this disease by backcrossing is being undertaken and resistant varieties may be expected soon.

BARLEY BREEDING

Malting Barleys

About 30 per cent. of the British barley crop is used for malting, and a large proportion of the farmers who grow barley hope to obtain good malting quality samples. The production of good malting barleys must therefore be one of the chief objectives of the barley breeder. Fortunately the combination of high yielding capacity with grain of good quality presents less difficulty than in the case of winter wheat. It is in fact found that the varieties favoured by the maltster are often those which give the highest yields, since there is a negative correlation between yield and the protein content of the grain. Very great advances in the production of high yielding malting barleys have been achieved in recent years through the hybridising of the best English malting barleys with high yielding short strawed

The introduction of disease resistance through a back crossing programme may be greatly accelerated by the use of an artificially heated and lighted glasshouse in which one or more extra generations may be obtained during the winter months. These wheat plants are approaching maturity in early January.

forms from Denmark. The variety Proctor, which now occupies well over half the barley acreage of this country, is the outstanding product of this programme, but other similar varieties are now being developed.

Feeding Barleys

Although large quantities of malting barley varieties are used for stock feed, the requirements of feeding barleys contrast in many ways with those of the malting barleys. Besides being less exacting in the attributes required by the maltster, feeding barleys must be able to stand up to much heavier manurial dressings than are applied to crops intended for malting. It is also desirable that the maximum proportion of the nitrogen applied to such crops should be converted into plant protein. Selection for a combination of these characters with high yielding capacity must also be an objective for the barley breeder, and it is possible that six-rowed varieties may be introduced for this purpose.

Time of Maturity

Earliness of maturity, or better, a series of varieties coming to maturity in an orderly sequence, can be of great value to the farmer in organising his harvesting operations. The provision of such a sequence of varieties is thus a problem to be undertaken by the breeder. However, there is a limit to the extent by which the time of maturity of a variety may be advanced if it is not to suffer a serious loss in yielding capacity.

Winter sown barleys may provide an alternative means of obtaining early maturity and are more likely to provide good malting grain, though unfortunately the best malting barleys at present available are not sufficiently hardy to survive the more severe British winters. Many farmers attempt to avoid this difficulty by drilling in late December or January, but this is not possible on any but the lightest land and the crop is still subject to damage if very cold weather follows. The development of winter hardy malting barleys is thus an important breeding objective, and the production of such varieties will be eagerly anticipated. The development of 'alternative' barleys which, though adequately hardy for autumn sowing, would give satisfactory yields if sown in the spring, would also be of great value.

Disease Resistance

The principal diseases attacking the barley crop are loose smut and powdery mildew. Loose smut can be controlled by hot water treatment of the grain and is not a major problem for the plant breeder, though he should be careful not to release varieties which are unduly susceptible.

Powdery mildew is a more serious disease, which may cause substantial losses in yield and quality of spring barleys and which also causes a marked loss in hardiness in winter sown crops. Fortunately a number of sources of resistance to mildew is known and the introduction of mildew resistance to the best malting and feeding barleys is an important breeding objective. Several mildew resistant varieties are already on the market and the release of others may be expected.

OAT BREEDING

The acreage of oats in Britain has fallen very markedly during the past 10 years, much of the land formerly sown with oats now carrying feeding barley. The reason for this is that although the two crops are of about equivalent feeding value, improvements in the feeding barley varieties now available have not until very recently been equalled by corresponding improvements in oats. At the same time, the grain quality of the oat crop, expressed in terms of oil content and kernel percentage, has tended to fall as yields have been increased. A number of most promising new oat varieties has been developed in recent years, however, and the downward trend in the popularity of the crop may now be halted.

Straw and Grain Yield

As in the case of the other cereal crops, yield is the most important character with which the oat breeder is concerned, but in the case of the oat crop the yield of straw is in many cases as important as that of grain. This is

Small scale yield trials are carried out as soon as a sufficient quantity of reasonably true breeding grain is available. This picture shows a trial of wheat selections in which a plot size of seven rows, each 10 ft. long, has been used. The border rows are discarded before the trial is harvested.

particularly true of the upland areas of the north and west, and in selecting oats for these areas the breeder must consider both straw and grain yields as essential breeding characters.

Adaptability

It was at one time considered that oat varieties exhibited marked ecological preferences; however, recent experience has shown that, apart from the specialised requirements for upland districts, some varieties are equally well adapted over very wide areas. The varieties Sun II and Blenda, for example, which represent over half of the oat acreage of England and Wales, seem to be equally suited to such widely differing localities as Cumberland, Dorset and the low rainfall areas of East Anglia. It thus appears that a primary task of the breeder is the production of general purpose oat varieties adapted to arable conditions throughout the country.

One of the chief causes of the diminishing popularity of the oat crop has been that the higher yielding varieties have not been able to stand up to high nitrogenous dressings as well as the newer barley varieties. At the same time the short strawed varieties of both spring and winter oats have not been sufficiently high yielding. In recent years, however, high yielding short strawed varieties have been released, and these may improve the popularity of the oat crop.

Winter oats are considerably less winter hardy than wheat or barley, and substantial losses may be caused in severe winters. Very hardy varieties are known from North America and Eastern Europe, however, and are being used for hybridisation with varieties suited to British conditions.

Disease Resistance

Substantial losses in yield may be caused to both spring and winter oats by powdery mildew. The disease is most serious in the spring sown varieties, though an associated reduction in hardiness in winter sown crops may be of importance. Crown rust may also cause very serious damage, especially in Devon and Cornwall. Varieties of both spring and winter oats showing resistance to these diseases have recently been developed by the Welsh Plant Breeding Station, and there is little doubt that further resistant varieties will become available in future years.

Root and stem eelworms may also cause serious damage in oats, losses being particularly serious in winter sown crops. Fortunately several oats, stemming from the variety Grey Winter, show resistance to the stem eelworm and are being used in breeding programmes. An oat showing resistance to the root eelworm has recently been reported from Denmark.

A recent survey has shown that the frit fly causes yield losses of up to 10 per cent in both tiller and panicle generations. Tiller stage losses are most severe on late sown crops, but losses at the panicle stage may occur on any crop. There is evidence of varietal resistance to tiller attack, and varieties showing this resistance are being used in breeding. There is, however, no evidence yet of resistance to attack in the panicle.

* * *

It can be seen from this review of cereal breeding in Britain that active work is in progress to meet most of the needs of the farming community. These breeding objectives may be grouped into three main categories: improvements in yield, improvements in grain quality and improvements in the reliability of the crops concerned. The third group covers such varied topics as straw strength, winter hardiness and disease resistance.

It is not always realised that it normally takes between 10 and 15 years to market a new cereal variety, measuring from the time when the hybrid is made. Thus, while improvements in such characters as yielding capacity and disease resistance would always be of value, it is also necessary for the plant breeder to anticipate the needs of the farming community some 15 to 20 years in advance, and to estimate its requirements in such matters as straw height or grain quality. Having planned his programme of work, it is also necessary for him to see it completed and to resist the temptation to redirect it towards objectives to which it is not well suited.

Hybrid Maize in the United States

by **Raymond Baker,** *Director of Maize Breeding Research, Pioneer Hi-Bred Corn Company, Johnston, Iowa, USA.*

No annual plant produces so much energy with so small an expenditure of man-labour as the maize grown in the great United States 'maize belt'. This is largely possible because of hybrid maize, and hybrid maize is perhaps the best example of the practical benefits of applying basic research.

The maize plant, because of its unique features, is an extremely 'willing pupil' for geneticists. First, maize has separate male and female flowers that make it easy to control pollination. Second, an individual maize plant produces a large number of seeds. One kernel planted in early May can produce 600-800 kernels of mature grain by 1st October. The third factor making maize ideal for the application of Mendelian genetics is the small quantity of seed needed to plant an acre.

These facts make it economical to produce hybrid seed at a relatively low cost each year. (Seed saved from a field of hybrid maize will not have the vigour and productivity of its parent plants. The farmer must buy 'new' first generation hybrid maize seed each year.) Without these factors making the cost of hybrid seed reasonable, the larger yields, better quality grain, and ability of hybrid plants to better withstand nature's stresses would be of considerably less value to farmers.

Early Hybrid Maize Breeding

While the origin and history of maize is not completely clear, what has happened to maize since the early 1900s is well documented. The story really begins with a young scientist named George Shull, doing basic research work to support the then 'new' theory of Mendelian genetics. Working with maize at Cold Springs Harbour on Long Island, Shull became interested in hybrid vigour.

To George Shull goes credit for publishing a clear-cut description of the practical mechanics for the application of hybrid vigour in maize—even though others had earlier noticed hybrid vigour in maize and suggested it be used. His paper, *A Pure-Line Method of Maize Breeding*, was published just 51 years ago, in May, 1909.

The rapid and successful development of hybrid maize in the United States was aided by another factor: an abundant supply of open-pollinated varieties with diverse background. When the European settlers first arrived in America, they found the native American Indians growing mainly two types of maize. Most widely grown was a maize that produced slender ears with only a few rows of hard, flinty kernels on each ear. Further south, along the Atlantic and Gulf Coasts, the natives grew large 'gourd-seed' maize—a much longer-season variety. The seed on these ears was narrow, long, and much softer than the short-season flint maize grown by the northern natives.

Neither the flinty, early-maturing maize of the north, nor the soft-kerneled, late-maturing gourdseed maize of the south, suited white farmers in the rich central maize-growing area of the United States. The flints matured

safely, but they were low-yielding. The gourdseed maize seldom matured before frost. But by planting the two kinds of maize together, and letting them inter-cross, farmers developed a new type of maize. It was higher yielding than either of the original two types, and it would normally ripen before cold weather.

From this chance mixture, farmers developed dent varieties that were used to produce more than 95 per cent. of the commercial maize in the United States before hybrids were developed. These same varieties, with their rich and diverse backgrounds, have been the source of inbreds with which today's high-yielding hybrids have been developed. In fact, all of today's high-yielding hybrids contain inbreds developed from these dent varieties, on at least one side of the hybrid cross. Some of our highest-yielding hybrids are made up of flints, or semi-flint inbreds on one side of the cross and soft dent type inbreds on the other side.

Inbreeding

To understand how hybrid maize improvement has come about, a basic knowledge of hybrid maize breeding is needed. The first step in the development of a hybrid maize is the development of inbred lines. Ears are selected from the best adapted maize varieties. Seed from each ear is planted in a single row and selected plants are self-pollinated; that is, pollen is placed on the silks of the same plant from which it came. After five or more generations of self-pollinations, a relatively pure, uniform line of maize is produced.

The first cycle of inbreds was developed from existing maize varieties, as they were the only source. In recent years most of the improved inbreds are so-called second, third, or even fourth cycle inbreds, produced by repeating the self-pollination and selection process with the best maize hybrids. This is a type of recurrent selection that makes it possible to combine the best germ plasm from many original sources.

The second step in the development of a hybrid is to cross two or more inbred lines. There is nothing magical about crossing maize inbreds—only a very few of the resulting hybrids are satisfactory for commercial production. New inbreds are usually tested in all possible combinations to find which combination of inbreds give the most productive hybrid. The final hybrid is thus the product of many years of careful selection and experimentation.

During this breeding period all pollinations are made by hand. Ear shoots are protected from stray pollen by being covered with small paper bags until after the silks emerge. Pollen from tassels that have also been protected is then applied to make the desired mating, and the pollinated ear shoot is again protected. In this way the parentage on both sides is definitely controlled.

Production of Hybrids

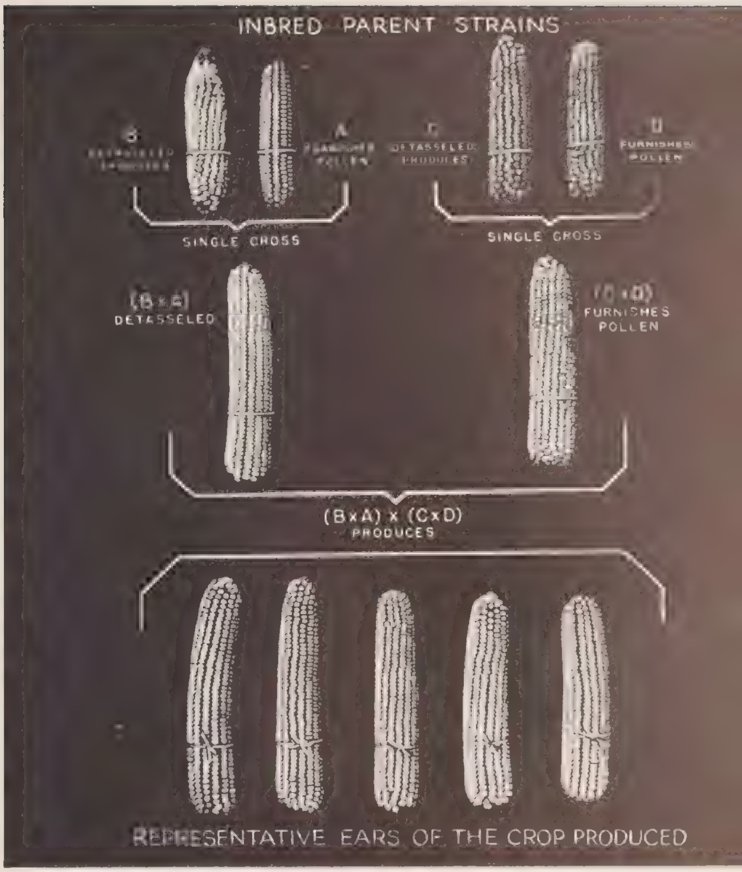
Inbred lines themselves are weak and low yielding, and it is almost unbelievable how these weak inbred lines immediately regain full vigour in the hybrid cross. Inbred lines are important because they represent pure types of seed which, when crossed together, produce predictable uniform kinds of maize. The simplest hybrid is a cross of two inbreds. Because the inbreds themselves are weak and low yielding, single crosses are expensive to produce; they make high yielding, extremely uniform hybrids and are preferred where uniformity is important.

Pioneer's hybrid variety 332, a typical modern maize dent hybrid.
(Photo: Pioneer Hi-Bred Corn Company)

Two unrelated single crosses can be crossed together to produce a 'double cross' hybrid. Since there are two steps involved, it requires two years to produce the double cross but it is much more economical to produce and is the most widely used hybrid in the United States. The double cross is less uniform, because it is derived from four inbreds instead of only two, and is adapted to a wide range of soil and weather conditions; also, it is much more consistent in yield than the average single cross. Over a period of years the average yield of the best double cross will equal that of the highest-yielding single cross.

A three-way cross has a single cross female and an inbred male, which makes it intermediate between the single cross and double cross in uniformity and adaptation to environ-

The two parents of modern dent maize. Left, *flint maize;* right, *gourdseed type maize.*
(Photo: Pioneer Hi-Bred Corn Company)



This diagram shows the method of crossing inbreds to product single crosses, and the resulting single crosses to product double cross hybrids.
(From: *USDA Farmer's Bulletin* No. 1744)

ment. Multiple crosses involving more than four lines are sometimes used to obtain wider genetic variability and adaptation; this is seldom needed, however, as double crosses can be made with very wide adaptation.

Hybrids are produced by planting two kinds of maize in the same field where they can be cross-pollinated. The cross-pollinating can be controlled by pulling the tassels from one kind (female parent) so it can be pollinated only by the male parent, then seed is saved only from the detasseled or female parent. The full hybrid vigour is only expressed in the first generation after the cross, so the farmer cannot save seed but must purchase first generation hybrid seed for planting each year.

Objectives in Maize Breeding

The evolution in maize production in the United States is best illustrated by the fact that the average maize belt farmer can produce a bushel of maize with only four minutes of man labour—or about one-third the time required before hybrid maize was available. The average yield of maize in the United States for the last five years has been 47 bushels per acre. Yields during a similar five-year period in the late 1920s, before hybrid maize became widely available, averaged 27 bushels per acre.

While increased yield of hybrid maize is the most spectacular gain achieved by maize breeders, other improvements have perhaps been just as important. The increased yield of maize in the United States is the result of a number of important cultural practices, such as the use of fertilisers, insecticides, fungicides and improved machinery, along with hybrid maize seed. No one of these improvements would have been very effective alone. Without the uniformity and lodging resistance of hybrid maize, for instance, modern maize harvesting machinery would not be practical.

The important factor in increased yield per acre in recent years is thicker plant population per acre. The average maize farmer is now using about 50 per cent. higher plant population than was used 20 years ago. Heavy nitrogen fertiliser application has been an important factor in mak-

ing this possible. These heavy plant populations put an additional stress on the maize plant for moisture and tend to make it more susceptible to stalk rot, causing lodging—a serious problem in commercial maize production. Hybrid maize breeders have improved the lodging resistance in modern hybrid maize considerably, but in the last few years they have barely kept abreast of the tendency for increased lodging due to the stress of heavier and heavier planting rates.

Hybrid Maize of the Future

The hybrid maize of the future will be more specialised and hybrids will be available for many more different uses. Hybrid maize breeding is especially adapted to this because over the last 40 years breeders have developed and catalogued thousands of pure inbred lines of maize, representing almost every characteristic.

The most important changes in the future, like the immediate past, will be to improve this partnership between fertilisers, chemical pest control, and modern machinery needed to produce higher yields. Farmers are rapidly changing from harvesting maize on the ear to using combine harvesters which shell maize in the field; this requires a maize that shells easily at high moisture without damaging the kernels (in the past, farmers needed a maize that was difficult to shell so as not to have a large shelled grain loss in the field when using ear maize pickers).

Other special cultural practices will require peculiar types of maize such as small dwarf plants for sprinkler type irrigation; special root-rot resistant types for growing maize successively on the same ground, and more stalk rot resistance to resist the stress of even higher plant populations. Higher plant populations may require other types of maize. There is a tendency towards barren plants at high plant populations. Prolific maize with more than one ear to the stalk may make it possible to produce maximum yield at low plant populations.

Male Sterile Maize

The development of male sterile maize, while it affects breeders and producers of hybrid maize more than it does the farmer, is an important step forward for, as mentioned earlier, tassels must be pulled from the maize plants being used as the female seed-producing parent so that only pollen from the male parent can fertilise the silks on the female parent. This is a fairly costly item in the production of hybrid maize seed.

In recent years, maize geneticists have discovered a special maize cytoplasm that prevents maize of the proper genetic make-up from shedding pollen. While this eliminates the need for detasseling the female seed parent, it presents a problem, for when planted in the farmer's field the following year, plants from this seed will not shed pollen and, without pollen, the plants produce only cobs—no kernels of grain. Currently, this difficulty is being overcome simply by mixing seed from ordinary female parents—seed which will produce plants that shed pollen—with seed produced by the male-sterile female parents. Thus there are enough pollen-shedding plants in the farmer's field to fertilise all the silks, even on those plants which themselves do not shed pollen.

It is possible to develop maize that, while not shedding pollen itself, will yield seed which does shed pollen. This is used as the male maize seed parent. To breed the 'male restorer gene' into maize seed parents is a complicated process—particularly since other characteristics must not be affected. But it can be done with some lines, and it offers the attraction of growing hybrid maize seed without any need for detasseling.

There is some indication that maize with the Texas source of sterile cytoplasm, now most widely used, tends to stunt the maize plants slightly. The blends of part sterile and normal cytoplasm have generally yielded more because the plants with sterile cytoplasm are relieved of the stress required to produce pollen, and so have more vigour left to produce grain. Maize carrying this inferior cytoplasm may never yield as much as normal when it has been restored, and has the stress of producing pollen.

Breeding Maize for Chemical Composition

The surplus maize problem in the United States has increased the interest in possible industrial uses of maize: the most promising one at present is high amylose starch. Ordinary commercial maize starch contains about 27 per cent. amylose (long unbranched chain molecules) and 73 per cent. amylopectin (branched chain molecules). Special high amylose maize have been developed with 80 per cent. amylose; commercially, 90 per cent. amylose is needed to be practical. The high amylose is suitable for making films and fibres. It is estimated that industry could use 40 to 100 million bushels per year.

Protein is another ingredient in maize that can be increased by breeding. Starch is most easily increased in high yielding hybrids. Actually, most high yielding hybrids are somewhat lower in percentage of protein than older maize varieties; maize varieties at 30 to 40 bushel yield levels generally tested around 10 per cent. protein. Hybrid maize today would average nearer $8\frac{1}{2}$ per cent. protein, at yield levels of 80 to 100 bushels per acre. High protein lines have been developed: hybrid maize could be increased from the present $8\frac{1}{2}$ per cent. to 12 per cent. protein with very little loss in yield. But maize protein is inferior because it is deficient in the essential amino acids, tryptophane and lysine, and although some breeding has been carried on to increase these important amino acids, it has not so far been successful. Until a high quality protein can be developed there will not be much demand for high protein maize.

A maize with higher oil content is another possible special type for the future. Present hybrids run from $3\frac{1}{2}$ per cent. to 5 per cent. oil, but maize has been tested with much higher oil percentages, and it would be quite easy to develop a hybrid with 6-7 per cent. oil.

There may be need for other 'specialised' maize hybrids in the future—for purposes which we cannot even imagine now. Fortunately, maize breeders have at their disposal thousands of inbreds with widely varying genetic characteristics. From these, it is possible to breed new hybrids to meet almost any future need.

Protecting Livestock against Disease

To a large extent, the malnutrition which is such a serious problem in many under-developed areas is due to shortage of animal protein. Obviously one of the key factors in helping to increase the farm animal and poultry populations which can be kept in many parts of the world is the control of livestock disease. Of possible methods of animal disease control, none is proving more successful than immunisation, and veterinary surgeons from under-developed countries are now receiving training in practical immunology in countries, including the United Kingdom and the United States, where the technique is commonly practised. In this article Dr. Howell introduces readers to the subject of immunology and discusses current trends in the use of vaccines.

by **D. G. Howell,** Ph.D., M.R.C.V.S.

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Most people have, at one time or another, received a protective inoculation against some particular disease or diseases. Children are now immunised as routine against such diseases as smallpox, whooping cough, diphtheria, poliomyelitis and tuberculosis. Those who travel overseas are often vaccinated against yellow fever, cholera and typhoid. These are practices familiar to us all. In veterinary medicine, too, procedures of this sort are of vital importance, since the success or future of a farming enterprise may depend on safeguarding the herd or flock against diseases often extreme in their severity.

The protection of a country's livestock industry against diseases of great economic importance, such as rinderpest, foot and mouth disease, and blue tongue of sheep, is a responsibility usually assumed by the government, and the manner in which it is carried out varies according to circumstances in different countries. It may be considered preferable to eradicate a disease, and by a rigorous policy of slaughter and control eventually to eliminate it entirely. This procedure can be applied to island countries like Great Britain, and in the end it may prove cheaper and more satisfactory when the effect is considered *in toto*. On the other hand, many countries, particularly those of continental Europe, Africa and South America, cannot practise such methods, and vaccination has to be resorted to.

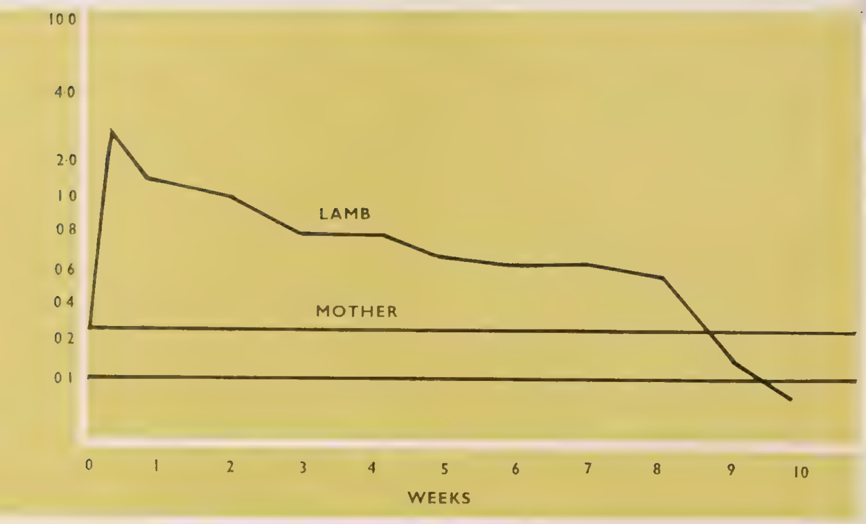
The term vaccination arose as a result of the discovery by Jenner, in the eighteenth century, that immunisation against smallpox could be achieved by inoculating human beings with a material obtained from the cow (*vacca*). This vaccine has stood the test of two centuries' experience and is still widely and effectively used. It is a classic example of the use of a living vaccine, since live virus is used, as opposed to other vaccines in which the micro-organisms are dead but still capable of exercising a protective function.

What is a Vaccine?

Vaccine is made from a variety of material. It may be, in fact, the fully virulent living organism responsible for the disease; it may be an avirulent variant; it may be virulent material that has been killed or inactivated by chemical or physical means; it may simply be derived from a product of growth of the organism, as for example those vaccines collectively described as toxoids. The choice of vaccine for a particular disease depends on the nature of the disease, its features and incidence, on the degree of immunity to be achieved, and so forth.

The ideal vaccine is one that is safe because it is dead (or, if living, is avirulent and has no tendency to increase in virulence in the animal), confers a sufficient degree of protection, does not interfere with the diagnosis of the disease in question, and is not too costly or difficult to

Fig. 1. The level of circulating antibodies to tetanus in a lamb born of an immunised mother. The level in the mother persisted at 0.2-0.4 units. The level in the lamb rose to 2.0-4.0 units within the first week of life. The protective level is shown at 0.1 unit.



Filtration of a virus vaccine—a stage in the purification of the vaccine.
(Photo: Glaxo Laboratories)

produce, keep or distribute. As far as food animals are concerned, no serious lesion at the site of injection must occur to impair the carcass quality.

Virulent Living Vaccines

Generally speaking, the most potent vaccines are living, and this is particularly so if they contain virulent material; this simulates as nearly as possible natural exposure to the disease, but suffers from being generally unsafe. Such vaccines can be and are, however, used in a number of instances, particularly if the route of vaccination is different from that associated with the pathogenesis of the disease. Vaccines are usually given by injection under the skin or into a muscle.

In a number of diseases, particularly those involving solely the respiratory tract, virulent living vaccines can be given. The classic example of such a procedure is furnished by one of the accepted methods of immunisation against contagious bovine pleuropneumonia—a disease of great economic importance in Africa and Australia. More than a hundred years ago it was shown that if virulent exudate from the lung of an affected animal was innoculated into the tip of the tail of a healthy animal, a high level of immunity was achieved in the latter. More refined vaccines and techniques have been introduced since then, but it is held by a number of people that this method is still the most satisfactory.

Poultry are susceptible to a disease of the respiratory tract called infectious laryngo-tracheitis. Immunity to it can be achieved by introducing virulent material into the bird's cloaca.

Use of Serum

The serum of immunised animals contains antibodies that can be injected into another animal to give temporary protection lasting for a few days or a few weeks—a procedure technically described as passive immunisation, as opposed to the active immunisation that results when vaccine is injected. By the former procedure the recipient's antibody-forming mechanism is not stimulated, whereas by the latter

it is, but passive immunisation has the advantage of conferring protection immediately, whereas the establishment of active immunity takes approximately 14 days.

In some conditions, when the hazard of injecting virulent material is too great, a procedure known as the 'serum simultaneous method' may be employed. In this method, immune serum and vaccine are given together, the antibodies in the serum repressing, as it were, the virulence of the vaccine. This procedure is standard practice in the United States for immunisation against swine fever. The big drawback to the use of virulent material, with or without serum, is that the causal organism of the disease is enabled to multiply in a susceptible animal and reservoirs of infection inevitably result. The use of such methods must presuppose that this is an acceptable risk, but in most instances they are best avoided.

Avirulent Living Vaccines

For most immunising procedures involving living agents, however, avirulent or attenuated strains of the infective agent are used as the basis of the vaccine. Fortunately for immunologists, microbial entities such as viruses and bacteria can undergo changes that may result in a loss of virulence without a corresponding loss in the ability to produce antibodies.

This phenomenon was first observed by Pasteur, who recognised its importance as a result of an accidental discovery. Some virulent organisms of the bacterium *Pasteurella septica* were left in his laboratory over a vacation and were found on testing to have lost their virulence. *P. septica* is normally responsible for a septicaemic condition in birds, but Pasteur found that birds inoculated with his avirulent strain did not contract the disease and were, moreover, solidly immune to exposure with a fully virulent strain.

Pasteur developed this principle and applied it to other diseases, such as anthrax, swine erysipelas and rabies. With the latter he found that, on passing the virus serially[1] in the rabbit, an attenuated strain was produced that could be used to immunise the dog. This procedure of attenuating a virus, by passing it serially through an animal normally not susceptible to the disease, has been applied to a number of important viral diseases, as, for example, swine fever and rinderpest. A modification of this theme is to be seen in the so-called 'avianised vaccines', which are produced by passing virulent virus serially through the embryonated hen egg. The classic example in veterinary medicine of a vaccine of this sort is that used for immunising dogs against canine distemper.

Tissue-Culture

In recent years great strides have been made on the propagation of living animal cells in the laboratory—the so-called tissue-culture technique. Tissue-culture preparations will support the growth of a number of animal viruses, and this system is being currently studied as a tool for their attenuation. A vaccine for the immunisation of dogs against canine hepatitis has been prepared by such a method. The virus responsible for this disease is only pathogenic for the dog; but if it is passed serially through tissue culture derived from the kidney of the pig, it loses its virulence for the dog, though can still be used to immunise it satisfactorily.

Again, however, there is the question of safety of these vaccines to be borne in mind. In veterinary medicine risks that could not be countenanced in human medicine may be accepted, which is why so many avirulent living vaccines are used in the treatment of diseases of animals. Nevertheless, there is always the fear of reversion to virulence once the attenuated strain gets back into its normal host, and for this reason dead vaccines of one sort or another continue to have wide application against a great many diseases.

Dead Vaccines

However, as a general rule, dead vaccines do not give the same degree of protection as living vaccines, and usually repeat injections have to be given. Immunologists also endeavour to enhance the potency of dead vaccines artificially, by various laboratory methods. One method of great importance in veterinary medicine is the incorporation of an adjuvant with the vaccine with the object of delaying the absorption of the vaccine from the site of injection, so that the animal's antibody mechanism can be subjected to a more prolonged stimulus. Various adjuvants have been used, but principally they fall into two categories—mineral oils and aluminium salts. Some of these vaccines with adjuvants are most successful; examples that can be quoted are the vaccines used to immunise pigs against swine erysipelas, sheep against pulpy kidney disease, enterotoxaemia, blackleg and braxy, and cattle against haemorrhagic septicaemia and foot and mouth disease.

Passive Immunity

The various kinds of vaccine so far described are for the production of active immunity. Reference has already been made to passive immunity (produced as a result of injecting an animal with the serum of a previously immunised animal): this form of inoculation is useful in the face of an outbreak, when immediate protection is required, or to protect an animal against a short-term risk, such as appearance at agricultural shows.

There is another form of passive immunity of particular interest in the veterinary field: if a pregnant animal is actively immunised, passive transference of immunity will take place from the mother to the young, either while it is still *in utero* or immediately after birth as a result of taking the colostrum. In rodents and primates this transference of immunity takes place *in utero*, but in farm animals it occurs via the colostrum. The reason for this variation is related to the structure of the placenta, the connecting link between mother and young *in utero*. In all animals at least one membrane separates the maternal and foetal circulations; in rodents there is only one membrane but in cattle, horses, pigs and sheep, there are five or six. In the former,

[1]Serial passage involves the inoculation of an animal (or laboratory culture) with a virus and subsequent recovery of the virus for reinoculation of a series of animals (or cultures).

Inoculation of fertile eggs with a virus—an early stage in the production of a typical virus vaccine.
(Photo: Glaxo Laboratories)

Filling vaccine into vials ready for issue. Strict sterile precautions are maintained.
(Photo: Glaxo Laboratories)

antibodies are able to pass across the placental barrier, but when the barrier is 'thick', as in farm animals, this is not possible and transference occurs via the colostrum.

This natural phenomenon is used to produce in the young animal immunity to specific diseases at birth, and is of great value in protecting the new-born animal against those conditions typically encountered in the first few days or weeks of life. Indeed, there seems to be a natural factor that results in a concentration of antibodies in the colostrum so that a high level of immunity is produced.

Figure 1 shows the relative levels of tetanus antibody in a ewe and her lamb. The ewe was vaccinated in pregnancy, and it will be seen that the level of antibody engendered in the lamb was approximately 10 times that in the mother. It will also be seen that the immunity in the lamb persisted for 10 weeks or so, sufficient to protect it against the surgical hazard of tetanus associated with castration.

Maternal vaccination is also used to protect the young animal against such diseases as lamb dysentery and enterotoxaemia, both of which can occur within the first few days of life, for active immunisation of the young animal takes about 14 days to develop, even if the vaccine is given at birth. The practice of maternal vaccination is therefore of real value and is widely adopted, particularly in sheep husbandry.

It has already been mentioned that vaccines must not cause a serious reaction at the site of injection, particularly in animals intended for food. Many veterinary vaccines have in the past been crude and their use was associated with the production of severe localised lesions, which might become infected, leaving a permanent blemish on the carcass. In countries such as New Zealand, which have a substantial export trade in high quality meat, this could be a serious matter. In recent years immunologists have paid much attention to this feature, and vaccines now in current use have been purified to remove as much foreign material as possible and are associated with little or no risk at the time of injection.

The Royal Society's silver gilt mace, seen here with the Society's Charter Book and inkstand, was presented by Charles II in 1662.

Three Hundred Years Old

The Royal Society of London, which is celebrating its tercentenary this July, may justly claim that in making its plans for the occasion it has looked as much to the present and future as to the past. It is the oldest scientific society or organised scientific academy which has enjoyed continued existence from its foundation onwards. It is neither a trivial thing nor to be over-emphasised that the 25 Fellows whom the Society has lately elected have signed their names in the same Charter Book as the 119 original or Charter Fellows and as Isaac Newton, elected in 1671 as the maker of the first reflecting telescope. Like the Charter Book with its unbroken sequence of names, the Society's Mace—shown on this page—was the gift of King Charles II and is still used regularly at meetings.

The Society was on the side of revolution by experiment from the beginning. Its Latin motto, taken from Horace, denotes a lack of compulsion on its Fellows 'to revere the word of any particular master'. Conversely, no Fellow, once elected, need be afraid from then on of making a fool of himself—quite an important point for progress. As for experiment, Robert Hooke, a physicist, was early required 'to furnish the Society every day they mett, with three or four considerable experiments'. Rather more than a century later, Sir Joseph Banks, botanist and President, developed the custom that every Sunday evening after dinner he held a 'conversation' at which objects of scientific interest were exhibited by host and guests. These occasions led to the larger 'Conversaziones' held yearly by the Society at Burlington House—and hence to the tercentenary Conversazione, with its special purpose of illustrating a selection of current lines of research in which British contributions have been, or are, important.

In this and other ways, the Royal Society is this July entertaining its 200 or so visitors from overseas countries to an up-to-date version of scientific hospitality—the showing by hosts of the best that they have to offer. Subjects chosen for illustration through exhibits include microbial genetics, natural and synthetic hormones, vitamins, and antibiotics—all of wide interest, and important in farming, industry or both. Special lectures by Fellows—who will cover between them many of the growing points of science—as well as visits to laboratories and research institutes, have been arranged.

The facts that the Society has 63 Foreign Members and that its celebrations are to be attended by more than 30 representatives of national academies and 125 representatives of universities in all parts of the world tell their own story. The Society has been international in interests and contacts from the beginning, and still is. One of its first joint secretaries, Henry Oldenburg, was held a prisoner in the Tower of London for two months on suspicion of 'dangerous designs and practices', aroused by a heavy foreign correspondence. Relations with Benjamin Franklin, distinguished as statesman as well as scientist, were not disturbed by the American War of Independence. Sir Humphry Davy, chemist and President, travelled in Europe by permission of Napoleon at a time when France and England were at war; and the toast of the Royal Society was drunk in his honour at a dinner held by a French learned society. German Foreign Members remained as such during both the 1914-18 and 1939-45 wars. Recently there have been exchanges of delegations with the Academy of Sciences of the USSR, and an agreement has been concluded for the exchange of senior scientists and research workers. In matters of international scientific organisation, the Society customarily acts on behalf of science in the United Kingdom.

In the concluding words of a short history written by Professor E. N. da C. Andrade, F.R.S., for the tercentenary: 'From being, in the early days, the preoccupation of a few curious spirits science has grown to be today a universal study, on the findings of which, rightly applied, peace among peoples and the prosperity of nations depend, but the principles of the Society remain the same: to promote the reliance on experiment and observation rather than on authority and to further the friendly cooperation of learned men without boundaries of race or creed'.

A. W. HASLETT.

Irrigation in the Middle East

by **A. F. Money-Kyrle,** *Formerly Research Associate in Agriculture, American University, Beirut.*

The author carried out a survey of agricultural research and development in Egypt, Turkey, Syria, Lebanon and Iran on behalf of the American University of Beirut with the help of a grant from the Ford Foundation. In the following article he discusses irrigation in the countries he has visited.

In parts of the Middle East with little or no rainfall, the limiting factor in agricultural production is water, not land. One should therefore consider the possibility of obtaining the maximum production per unit of water rather than per unit of land.

All water for irrigation is ultimately derived from rainfall. Rainfall depends upon many factors such as latitude, distance from the sea coast, the altitude and the prevailing winds. There is both theory and evidence to suggest that rainfall is influenced by the vegetation. The American forester ZON (11) put forward the hypothesis that forests influence the climate of areas to the leaward by transpiring large quantities of water vapour into the air. PENMAN (10) has shown that provided water is abundant and there is a closed vegetation on the ground, most short green crops transpire at an equal rate, or between 60 and 80 per cent. of the rate that water is evaporated from a free surface. In a forest, much more water can be stored in the root zone than in other types of vegetation, so that the vegetation can transpire at its maximum rate for much longer periods of the year than grasses. They would thus be expected to have a bigger influence on climate.

Evidence that forests influence rainfall is given by GEIGER (4), who reported that a comparison of rainfall in the Ituri forest of the Belgian Congo showed that forest areas enjoyed 30 per cent. more rainfall than neighbouring open lands. BURGERS (2) reported that afforestation had increased rainfall in parts of Spain by 6-12 per cent. in wet years and 16 per cent. in dry. Perhaps the best evidence that forests influence rainfall is given in a paper by MARTIN (6) who studied the rainfall at St. Sever in the Landes before and after their reafforestation. Although the rainfall was similar for both periods at Toulouse, there was a 32 per cent. increase in rainfall at St. Sever after the afforestation of the Landes. It is probable that the study of the influence of vegetation on rainfall could be put on a quantitative basis.

The storage of rain water should begin as soon as the rain has fallen—namely, on the watersheds. Excessive grazing by goats and destruction of the vegetation causes rapid run-off of water and flooding of rivers. Control of grazing leads to development of denser vegetation and improves the penetration of rain water and the water holding capacity of the soil, so that stream and river flow are more evenly distributed throughout the year and fewer storage reservoirs are necessary.

Irrigation Need

Since water is so valuable, the estimation of irrigation need is very important. PENMAN (10) of Rothamsted has made a big contribution to this problem. The energy available for the evaporation of water is derived from the sun and from winds which may have been previously warmed by the sun. Only a certain amount of energy strikes a square yard of ground and is available for evaporation. As already mentioned, Penman found that a short green crop completely covering the ground and adequately supplied with water transpired between 60 and 80 per cent. of the evaporation

from a free surface of water. The evaporation from a free surface of water could be calculated from meteorological data. The short green crop transpired less than a free surface of water because the reflection was different and because the stomata of the leaves offered some obstacle to the free diffusion of gases. Penman assumed that for maximum growth the stomata must be open, so that for maximum growth the plant must not be short of water. If water is short, the stomata close and transpiration may be reduced to perhaps only 10 per cent. of the evaporation of a free surface of water, but growth under these conditions is greatly reduced. Suppose the crop is a row crop and does not provide complete cover: transpiration will of course be greatly reduced, but this method of Penman can be most valuable for the engineer or agriculturalist.

The time to irrigate is normally determined either at fixed intervals or by the look of the crop. It can also be determined by instruments such as the tensiometer, which measures the soil moisture electrically, by instruments which simulate evaporation of the crop and measure water evaporated by a porous pad, or by calculation.

The quantities of irrigation water to be applied at one time depend on the soil. The soil is at field capacity when it is holding as much water as it can. It is at wilting point when it is unable to supply the needs of a crop and the crop wilts. The available water is the difference between these two values. Thus only enough water should be put on the soil to achieve field capacity, otherwise much loss of water will result.

Methods of Applying Water

Several methods of irrigation are employed in the Middle East. In the old days, the irrigation system used in Egypt was basin irrigation. Large basins of several hundred acres were made and at the time of the Nile flood, up to 3ft. of water were run into the basin and the basin was closed. Crops were planted on the mud as the water receded, and as the soil dried the roots grew down into the deeper, moist layers.

When the cotton crop was introduced in 1820, perennial irrigation became necessary. The Nile water was stored in dams, and the fields were irrigated at regular intervals. For cotton, the water was allowed to flow into the furrows between the crop; for wheat, small basins were used and the water run in to a depth of 4in. This system is the one used chiefly in Iran.

Furrow irrigation is used in certain modern farms in Turkey and is common in America. Furrows with a gentle gradient are made mechanically and the water is allowed to flow in at the top. This system is a very effective one with modern machinery but must be carried out carefully. The border strip method is rather similar but uses raised ridges to guide the water.

In sprinkler irrigation, developed in the USA, light portable aluminium pipes and sprinklers are used and the whole can be quickly moved. This system is very effective on sloping ground, for pastures, and whenever percolation into the soil is rapid. It is economical in water and gives very accurate control; but owing to its high initial cost, it is little used as yet in most parts of the Middle East.

Other methods of irrigation are used, such as bunding (making depressions in the land to retain rain water) and the controlled use of flood water in desert areas.

Mistakes in Irrigation

Much land in the Middle East has been ruined by irrigation without drainage. In soils with no drainage, the water moves upwards by capillary action and eventually a deposit of salt is left on the surface, making the land infertile until the salt has been washed out. Under certain conditions, the salt may react and give rise to alkaline soils; these may be practically impermeable, making leaching and reclamation very costly.

To prevent the formation of saline and alkaline soils, all irrigation systems should have adequate drainage so that the tendency will be for salts to move downward rather than upward. These drainage systems must have proper outlets and if necessary the water must be removed by pumps. Although this may seem obvious, an FAO report (3) states that approximately 800,000 acres have been rendered barren in the Punjab by salinity.

Another very serious and common effect of a high water table is to prevent oxygen exchange and so limit the root zone of plants to a narrow surface layer. Dr. Lawrence Balls, who for many years directed botanical research in Egypt, in a fascinating study (1) of the yields of the cotton crop, isolates the different factors responsible for changes in the yield of cotton. He concludes that excessive use of water, and seepage from canals and the barrage pond, saturate the soil so much that when the annual flood comes, the water table in the delta rises as much as one metre one month earlier than previously. He estimates that this rise in the water table causes Egypt an annual loss of £E20m. It is estimated (3) that only 30 per cent. of the irrigated area in Egypt is properly drained and it has been suggested that tile drains at a depth of between 47in. and 70in. should replace the shallow open ditches which occupy 10 per cent. of the area.

Yet another fault in irrigation is overwatering, which is very expensive and tends to waterlog the soil and raise the level of the water table. Dr. Zein-el-Abedine and Dr. El-Shal at Cairo University made a study of the different quantities of water needed to irrigate crops in the province of Munafir. The maximum yield was obtained with 60 per cent. of the conventional quantities of water. If this water could be used elsewhere, it would of course enormously increase the irrigated area.

The question of maintenance of both irrigation and drainage canals has to be borne in mind; dry periods are necessary for the control of weeds and parasites.

IRRIGATION PRACTICES IN DIFFERENT COUNTRIES

Egypt

The principal crops grown in Egypt are maize, wheat, cotton and berseem, *Trifolium alexandrinum*. Other crops of lesser importance are barley, rice, sorghum, sugar cane and various fruits. The present area under irrigation is

Destruction of forests in the water shed of the Euphrates (above) results in river flood (below).

Five-acre areas of desert ready for irrigation. Below, reclaimed desert planted with citrus and mangoes. Both photographs were taken at Moudiriah-et-Tahrir, Egypt.

about six million acres, which includes the Nile delta and a narrow strip along the Nile. If water storage is enlarged, it is hoped to increase this area to 10 million acres, and this may very well be possible if water consumption can be reduced. Until recently it was thought that only the fertile silt deposited by the Nile in the Nile valley and delta was worth cultivating. However, sandy areas in the Moudiriah-et-Tahrir or Liberation Province are being cultivated with water from the Nile.

Since much of the Middle East is desert, the problem of cultivation in the desert is important. As the desert is large and the supply of water limited, one must think in terms of production per unit of water, rather than per unit of land. Secondly, a sandy medium is not ideal for plant growth and one should study the quickest and most economical method of building up a fertile soil. Soil is formed rapidly in the desert wherever there is water: one must study which types of vegetation build up fertile soil most rapidly and which types build up such soil with least water. Thus most plants produce 1kg of dry organic matter for between 300kg and 1,000kg of water transpired. As organic matter dies, it is oxidised by bacteria and only a part of this becomes humus; to build up soil organic

The line of a kanat, or water channel, in Iran.

Irrigated land in the Ghouta, Damascus.

matter, it must be applied at a greater rate than it is broken down—and it is broken down fast under the high temperature of a tropical climate.

What types of vegetation will most effectively utilise applied water to produce soil? Our first reaction is probably to think of some desert plant which seems to require very little water; but this would also have the disadvantage of growing very slowly. If water is applied to sand it percolates rapidly away. Thus one should choose a vegetation with a rapidly expanding and extensive root system. One does not wish to add more fertiliser than is necessary. A grass/legume mixture, such as alfalfa with a grass, might well be the most suitable soil building crop with which to start.

Dr. El-Ashkar of Alexandria University found that on one soil in the Liberation Province, the field capacity had been increased five times after three years' cropping. This emphasises the possibilities which exact experiments on soil formation in sand, carried out in lysimeters, might hold.

The work of Melsted, in the USA, on the maintenance of organic matter in arable soils may be of considerable importance in this connection. MELSTED (7) concluded that soil organic matter can be maintained or even built up under intensive cropping systems, provided sufficient quantities of carbonaceous materials and nitrogen are added to the soil. Melsted's data indicated that it was shortage of nitrogen rather than crop residues that retards the formation of soil organic matter. He found that using increased amounts of nitrogen tends to decrease the rate at which nitrogen, and hence organic matter, is being lost from the soil.

To cause a build-up in organic matter, the farmer must add more fertiliser than the harvested crops are removing. He must add nitrogen for the crop and nitrogen for the soil micro-organisms; apparently if he does this not only is the organic matter in the soil increased but the nitrogen lost from the soil is diminished—a rather unexpected result.

Liberation Province, or Moudiriah-et-Tahrir lies to the west of a line drawn between Cairo and Alexandria. Here water from the Nile is used to irrigate desert land; the first part of the project is to reclaim 25,000 acres, which may one day be extended to a million. The stages in reclamation are as follows. First, areas of 200 acres are marked out with a ditcher, then roads are built with bulldozers (silt, brought

by barges, is mechanically mixed with sand to stabilise the road surface). The fields are roughly levelled into five-acre areas by means of a scraper and are finely levelled by a land leveller. The canals are then made and lined with cement blocks. The land is flooded with Nile water to a depth of 2-3ft. in order to deposit silt, and then organic matter is spread over the land at the rate of 10cu. yd. per acre. Legumes such as alfalfa, berseem, or lupines are first grown and the land may afterwards be sown to cereals or planted with mangoes interplanted with citrus. The Nile water is supplemented by water from underground wells which keep the water table at a depth of 7-8yd., each well supplying water for about 250 acres. Friesian cattle graze the alfalfa and Hereford cattle have also been imported.

Turkey

The principal irrigated crop in Turkey is cotton, although many other crops are being introduced. The report of the International Bank (5) shows that 247,000 acres are now under irrigation, but several projects are under way and it is estimated that about one million acres will be irrigated. Most of Turkey has very little summer rain and irrigation should enormously increase crop production.

To assist in the development of irrigation, Turkey has established several modern irrigation research and development centres—at Tarsus, Menemen, Cumra and Iskisehir. The main centre, at Tarsus, is one of the most interesting stations in the Middle East. Experiments are carried out on the best methods of irrigation, quantities of water and intervals between irrigation, fertiliser application and rotations under irrigation.

Syria

The most important irrigated crop in Syria is cotton. Irrigation is developing rapidly and in an FAO report (3) it is estimated that nearly a million acres are irrigated and that the area could be doubled. One of the biggest schemes is the drainage and irrigation of the Ghab swamp along the Orontes river, and in addition, pump irrigation is being rapidly extended along the Euphrates.

One of the oldest irrigated areas in the world is the Ghouta surrounding Damascus: the small fields of one or two acres, surrounded by walnut or poplar trees, make a very attractive aspect. Intensive mixed farming is carried out with orchards of apricots, apples, peaches, cherries and olives in which wheat, hemp or berseem may be grown between the trees.

Lebanon

The main irrigated crops in the Lebanon are citrus, bananas and vegetables, along the coastal strip. Nearly 118,000 acres are under irrigation and it is estimated that the irrigated area could be extended to 247,000 acres. The largest project is that of the Litani river in South Lebanon.

Iran

In Iran, the crops chiefly irrigated are barley, rice, maize and millet. Other important crops are pulses, cotton, sugar beet, oil seeds and tobacco. About four million acres are irrigated in Iran and it is estimated that the irrigated area could be doubled (the irrigated land is about 40 per cent. of the cultivated area). With present methods of irrigation heavy losses occur, and with better methods of supply and application of water, the irrigated area could again be increased.

Rainfall is under 12in. over most of the Iranian plateau and the desert regions receive less than 5in. per year. Owing to excessive deforestation and excessive grazing of the upper catchment areas, there is a very rapid run off, and a tendency for rapid silting of reservoirs. For snow-fed rivers, the maximum to average annual discharge is of the order of four to one.

Seventy-two per cent. of the irrigated area in Iran is supplied by kanat, an underground water channel tapping the water table at a point higher than that to be irrigated, and delivering the water by gravity to the surface. The channels are about 4ft. high by 2ft. wide with shafts at 30-80yd. intervals; the average depth at source is 30yd. and the average length 4,000yd. The average delivery is 11 imperial gallons per second—which is sufficient to irrigate about 75 acres. Pumped wells probably possess great advantages over a kanat.

Other countries

The author has no personal experience of Sudan, Jordan and Iraq but he understands that in Iraq 3.7 million acres are irrigated by the Tigris and 3.1 million acres by the Euphrates, and that silting of canals, lack of drainage, flooding and salinity are important problems (3).

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Spraying insecticide in the Migori river system, using Kiekens Dekker machines.
(Photo: Kenya Information Services)

The economics of insecticides against Tsetse Flies in Kenya

by **P. E. Glover** and **E. C. Trump,** *Department of Veterinary Services, Kenya.*

Trypanosomiasis, a fatal disease transmitted by the tsetse fly to both man and animals, is prevalent in Kenya and a cause of grave concern both to the Medical and Veterinary Departments. Until 1949, the most important control measure was the clearing of bush in which the tsetse lives and some therapeutic treatment of infected cattle was also undertaken.

The Nyanza Province is infested by the lake-side tsetse fly, *Glossina palpalis*, which transmits Gambian sleeping sickness to man. Against this species, 'hand catching' (SYMES and VANE [8] and GLASGOW and DUFFY [5]) was successfully used on a limited scale on some of the tributaries of the Kuja River in South Nyanza, but it could not be applied on an extensive scale.

It became evident, therefore, that any large-scale attack upon this disease must inevitably be governed by economic considerations, and the Tsetse Control Section of the Kenya Veterinary Department has devoted much attention to comparing the costs of the various methods employed, to discover the most economical means. Bush clearance, originally thought to be the only sure way of eradicating tsetse flies, had the serious disadvantage of requiring recurrent expenditure on the control of regrowth, even in areas where settlement schemes were in progress. This par-

An aerial view of a riverine habitat of Glossina palpalis.
(Photo: Kenya Information Services)

ticularly applied to the extensive riverine clearings made in Nyanza (WILSON [9]).

Consequently, it was decided to experiment with insecticides to discover whether they could be successfully employed in eradicating tsetse fly at a more reasonable cost than other methods. Insecticides were first used in 1949 in attempts to 'de-fly' trains passing through tsetse country. Trains travelling from Mombasa to Nairobi were made to pass through an improvised fog tunnel operated by a TIFA machine (LEWIS [7]). *Glossina longipennis* and, to a lesser extent, two other tsetse species are carried by trains from the bush country into farming areas further up the line. Unfortunately 'fogging' had many practical difficulties, not the least of which was to ensure that each train travelled through the tunnel slowly enough to allow the fog to take effect. The method was expensive and not very satisfactory.

In 1951, further tests against flies transported by trains were carried out by applying coarse droplet sprays to the external parts of the carriages, trucks and oil tankers, with knapsack type pressure pumps (FAIRCLOUGH [3]). Some success was achieved, but again the cost was too high.

In 1953, outbreaks of animal trypanosomiasis on farms adjoining the railway line stimulated a further attempt at 'de-flying' trains. This time a new type of machine called the 'Swingfog' was used (FAIRCLOUGH [3]). The machine showed great promise: it could produce insecticidal fogs more cheaply than any other type of apparatus in use at the time; it was portable; and it emitted, for its size, a very large volume of dense fog. 'Fogging' was carried out by two machine-laden operators starting from opposite ends of trains at Makindu, a station about half-way between Nairobi and Mombasa. In this way the number of flies caught on trains could be reduced by about 70 per cent. at an expenditure of approximately £1,000 a year, including the price of the two machines, the insecticide, the operators' wages and maintenance. As about 2,000 trains (five or six per day) could be treated, the cost of 'fogging' one train worked out at about 10s. The insecticide used was 15 per cent. DDT dissolved in 'Sovacide F', a high-quality kerosine.

An enquiry into the number of animals dosed annually for trypanosomiasis in the areas concerned showed that the use of drugs was very much more economical than the 'de-flying' of trains with insecticides, the cost of which had been proved excessive. Therefore, the latter method was abandoned in favour of the therapeutic treatment of stock. It is obvious that insecticides can be used economically only when their cost is less than, and their effect as great as, that of bush clearing or drug treatment.

History of Control in Nyanza

The second series of tests, designed to determine whether insecticides could be employed economically against tsetse flies, was initiated in 1951 during the campaign being waged in Nyanza against sleeping sickness.

The history of the Tsetse Control Section's fight against this form of trypanosomiasis begins when, at the turn of the century, a serious epidemic of human sleeping sickness swept the shores of Lake Victoria, taking a toll, in Uganda alone, of about 300,000 lives in six years (BUXTON [1]). Proof was soon obtained that the vector of this disease, which was of the Gambian type, was *Glossina palpalis*, the tsetse fly which inhabits the shore of the lake and the rivers flowing into it. By 1911, the epidemic had abated considerably, though local sporadic 'flare-ups' continued to occur from time to time.

In 1948-9, an outbreak of sleeping sickness occurred amongst the people around Kibigori in the Nyando River basin of Central Nyanza. Early measures against it consisted of clearing the bush along the main river and its tributaries for a total length of 20 miles at a cost of about £200 per mile. It became increasingly evident, however, that the control of regrowth would constitute a heavy annual recurrent expenditure and that, as the recruitment of labour was becoming more and more difficult, an alternative method must be found (WILSON [9]).

In 1951, with the assistance of the Colonial Insecticide Research Unit at Entebbe, an experiment was initiated to spray insecticide on the vegetation along the water's edge or along paths cut near the stream bed. (The Colonial Insecticide Research Unit had previously been testing the value of insecticides against *G. palpalis*, by spraying vegetation on an island in Lake Victoria—WOODCOCK [10].) The insecticide was applied by men equipped with knapsack pressure pumps, and a team of three men, spraying both banks, was able to treat $2\frac{1}{2}$-3 miles of river a day. The insecticide first used was a 50 per cent. DDT paste obtained

in 11lb. tins. This was mixed with water to produce a concentration of 5 per cent. DDT. Dr. Wilson, who was in charge of the Kenya Tsetse Control Unit at that time, reported:—

> Four complete applications to 20 miles of river banks were made between February and May, 1951, and 165 tins of 50 per cent. DDT paste in addition to 40gal. DDT emulsion were used. A total, therefore, of 1,107lb. DDT was applied to 80 miles of fringing riverine vegetation, an approximate average of 13.8lb. per mile on each application, or a total of 55.2lb. per mile during the four applications . . .
>
> The residual effect of the spray on the vegetation after 14 days' exposure was excellent. In the first experiment carried out in February when rainfall was low, 20 *G.palpalis* were exposed for 20 seconds on vegetation collected 14 days after spraying. Twelve of the exposed flies were dead 18 hours later, while only two out of 20 control flies had died. In a similar experiment in March, 30 out of 31 flies had died within 16 hours, while only one control fly died. The residual effect, therefore, of the DDT deposit on vegetation at this rate of spraying in dry weather after 14 days' exposure could be considered satisfactory.
>
> Following the spraying in February, March and April, the total number of tsetses caught in all five blocks on the Mbogo River during weekly patrols along each bank dropped from 660 flies caught in January to 17 in April . . .
>
> During June, 1952, 17 months after spraying operations had commenced, no flies were caught in blocks W, T, P, Q, R and S and only one was caught on the adjacent block U on the Ainamotua.
>
> [Both these rivers are tributaries of the Nyando.]

This use of 5 per cent. DDT spray on fringing vegetation resulted in the extermination of *G.palpalis* from about 40 miles of river, at a cost of £42 per river mile—a 'breakthrough' which was to have far-reaching results in the Nyanza Province. For the next two years work on the Nyando River and its tributaries was limited to the respraying of the areas where odd flies recurred. But in 1954 it was decided to use insecticides in an attempt to exterminate *G.palpalis* from the whole of the Nyando River basin. The choice fell on a Shell product, 'Arkotine' S.D.18[1], which consisted of an emulsion containing 15 per cent. w/v technical DDT, diluted with water to give a final strength of five per cent. DDT. This was applied to fringing vegetation four times at fortnightly intervals (FAIRCLOUGH and THOMSON [4]).

The main work was finished by the middle of 1955. It was then found that the fly had extended beyond its former limits into the head waters of the rivers. Treatment of these areas was completed in April, 1956, and the fly had been exterminated from 137 miles of river, covering an area of 300 square miles, at a final cost of £68 per river mile, £40 of which represented the cost of insecticide, the remainder covering expenditure on such items as transport, path cutting and wages. No *G.palpalis* have been caught in the Nyando River basin since April, 1956.

South Nyanza Project

The success of this scheme led to the launching of a similar but larger project in South Nyanza, where there had been a serious endemic focus of Gambian sleeping sickness for a long time. Between 1950 and 1954, 666 cases of sleeping sickness were reported in this area.

Various methods were tested to exterminate *G.palpalis* from the rivers. From 1948 to 1951, total clearing of bush, coupled with discriminative clearing, was found to be very effective on several of the rivers of the Kuja-Migori system, but the cost of clearing hundreds of miles of river was uneconomical (i.e., £200-300 per river mile), while there still remained the problem of controlling regrowth (WILSON [9]).

At the end of 1952, the medical officer at the Macalder Mines, which lie in the fork between the confluence of the Kuja and the Kigori rivers, asked for assistance in dealing with the high incidence of sleeping sickness amongst the mine workers. Consequently, between early January and the end of March, 1953, narrow paths cut on both banks as near to the water as possible along seven miles of the Kuja, and 14 miles of the Migori rivers were sprayed four times with Arkotine S.D.18, using Four Oaks shoulder sprayers (GLOVER *et al.* [6]).

In the month before spraying began, 4,651 *G.palpalis* were caught on these lengths of river. After the first spraying, 1,821 flies were caught, after the second, 560, after the third, 132, and after the fourth, 16. The cost of this was £31 per river mile, excluding staff wages and transport. Although the areas treated were fairly well isolated at either end by the anti-tsetse clearings made in the past, the fly numbers began to build up again gradually, until in August, 1953, 362 were caught over the 21 miles which had been sprayed.

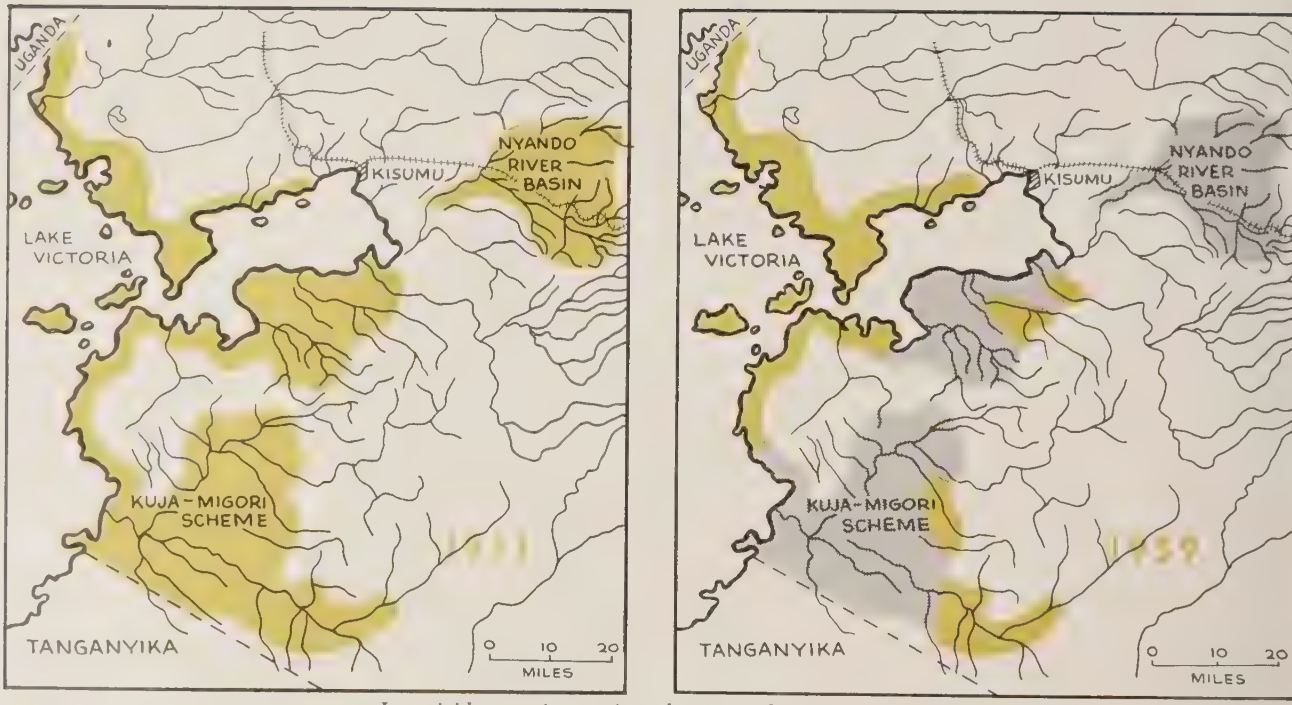
Subsequently a plan was put forward to the Provincial Team for the clearance of 65 miles of the Kuja and Migori rivers and 14 miles on the lake shore at an estimated cost of £10,000. This proposal was never implemented owing to shortage of labour and the reluctance of the local people to settle the cleared areas.

At the end of 1954, a scheme designed to exterminate *G.palpalis* from a large proportion of the area was initiated in collaboration with the Medical Department and financed partly by funds from the USA International Cooperation Administration. The scheme was divided into six phases covering different parts of the river system, and consisted of a combination of spraying fringing vegetation with insecticide and the creation of cleared barriers to prevent re-infestation from untreated areas (GLOVER *et al.* [6]).

Initially, different makes of pressure pumps with lances 4-5ft. long were used and various types of nozzles tested. The 'Eclipse' sprayer fitted with a lance that gives a fan-shaped spray proved to be the strongest and most efficient. It is a little more expensive (£17) than some other types but needs pumping up only once each time the container is filled with insecticide. The vegetation on both sides of a path for about 500 yards can be sprayed with one three-gallon filling. Two operators walk on either side of each cut path at about two miles per hour, slowly moving the spray lances up and down from ground level to about 5ft., making sure, meantime, that the spray falls evenly on the leaves and stems of the plants.

In 1956, a new type of portable petrol-driven, mechanical mist-blower, the Kiekens Dekker, was tested. This machine is carried on the back with shoulder straps and weighs about 30lb. The insecticide containers are fixed to the operator's chest; they hold half a gallon of insecticide and

[1]'Arkotine' is a Shell trade mark.



Insecticide spraying against sleeping sickness in Kenya.

Sleeping Sickness Areas *Reclaimed by spraying insecticides*

are detachable, so that refills can be fitted in a few minutes. This apparatus proved to be very efficient, producing a mist which is blasted into the undergrowth, providing an even cover of insecticide on the leaves and stems and penetrating deeply into the undergrowth. It uses about the same quantity of insecticide as the Eclipse sprayer and costs about £80. From the middle of 1956 onwards, both Eclipse and Kiekens Dekker sprayers were used on this scheme.

Use of Dieldrin

In November, 1955, a new Shell product, 'Dieldrex 15'[1], was tested in collaboration with the Colonial Pesticides Research Unit. The results of these tests were so promising that, on the advice of the CPRU (Burnett *et al* [2]), 'Arkotine' was replaced by 'Dieldrex 15', even though the latter costs much more. Experiments showed that, under field conditions, after 19 days at a dilution of 1.8 per cent. 'Dieldrex 15' still ensured a 90 per cent. kill. The actual cost of the spray at this dilution, therefore, worked out slightly in favour of 'Dieldrex'. Moreover, the interval between sprayings could be increased to three weeks. From the beginning of 1956 onwards, 'Dieldrex 15' was used exclusively on this scheme.

In Kenya, *G.palpalis* lives only on the lake shore and in riverine vegetation connected with the lake, and it is upon this practical ecological fact that our work is based. On the rivers (except for the Kabuoch Forest on the Upper Kuja), the vegetation in which *G.palpalis* occurs is seldom more than 60yd. wide on either bank. Work on the Nyando River basin had shown that all that was necessary in these circumstances was to cut a path, sufficiently wide to walk with a spraying machine, on either bank as near to the water's edge as possible. Whenever the width of the vegetation exceeded 60yd., further paths had to be cut at 60-yard intervals (Fairclough and Thomson [4]).

By the end of 1958, *G.palpalis* had been exterminated from more than 300 miles of the Kuja-Migori river system, covering an area of about 900 square miles, at a cost of £38,100. The average expenditure per river mile was £120. This, however, included cutting barriers and spray paths, as well as the cost of insecticides (about £25 per river mile), vehicles, transport, wages and supervision. Vehicles and barrier clearings were not included when estimating the costs of previous sprayings. The number of cases of sleeping sickness reported dropped from 157 in 1950 to 22 in 1958. Between 1954 and 1955 alone, they dropped from 145 to 66.

Despite inadequate funds, from the end of 1958 there has been steady progress in this area and approximately 100 more miles of river have been sprayed, including the great Kabuoch Forest on the Upper Kuja. About 100 miles of the Upper Migori river and about 20 miles of the Sare still require treatment; this will take about three years to complete. The fly will then have been exterminated from more than 500 miles of river, covering an area of about 1,500 square miles.

A phenomenon similar to that encountered on the Nyando River scheme occurred here when, after the initial spraying, *G.palpalis* were found on some of the rivers in

[1]'Dieldrex' is a Shell trade mark. 'Dieldrex 15' is an emulsifiable concentrate containing 18 per cent. dieldrin w/v.

areas where they had not previously existed. Therefore, the importance of intensive survey both before and after spraying operations cannot be too strongly stressed.

So successful have insecticides proved against *G.palpalis* that a plan has now been put forward to exterminate Gambian sleeping sickness from the Nyanza Province and, as a corollary, from the whole of Kenya.

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Shell Appoints New Agricultural Research Director

Dr. R. A. E. Galley, Ph.D., F.R.I.C., since 1953 Director of the Tropical Products Institute in the UK, on 1st July succeeded Dr. J. E. Hardy as Manager and Director of Research at 'Shell' Research Limited's Woodstock Agricultural Research Centre, near Sittingbourne, Kent.

A chemist by training (B.Sc. at Imperial College, London, 1930; Ph.D. 1932), Dr. Galley has been concerned since his appointment as Director of the Tropical Products Institute (and also of Colonial Pesticides Research) with research on natural products and pesticides in both the UK and overseas units. During this period he has made on-the-spot studies in many parts of the world and is particularly well known in East, Central and West Africa, and in the West Indies. He is a member of the Councils of both the Society of Chemical Industry and of the Royal Institute of Chemistry, of which he was elected a Fellow in 1944.

Since 1949, Dr. Galley has been a member of the World Health Organisation Expert Panel on pesticides and has four times been Chairman of the WHO Expert Committee on Pesticides; in addition, he has served as a consultant at WHO Headquarters in Geneva, and in Yugoslavia.

Born in 1909, Robert Galley was educated at Colfe's Grammar School and at Imperial College, London. After attaining his Ph.D. in 1932, he spent two years with the Wool Industries Research Association, working on what he describes as 'unshrinkability'. From 1934 to 1937 he worked with the War Department Chemist at Woolwich, after which he decided to try his hand at teaching, spending two years at the Sir John Cass College.

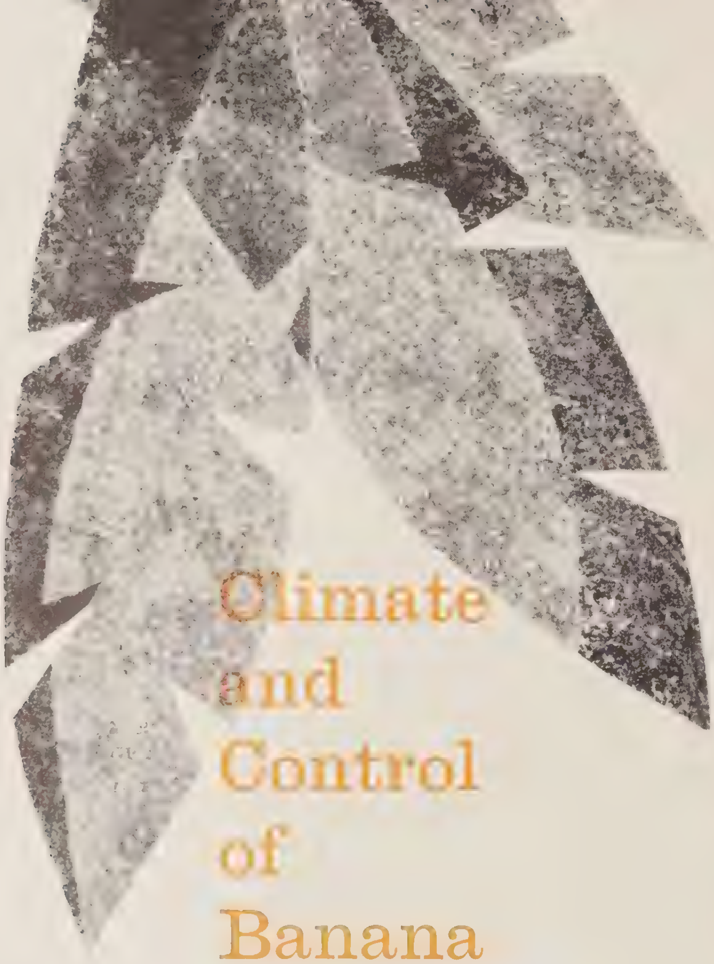
With the outbreak of war in 1939, Galley was recalled to join his old War Department unit which, however, had by this time been transferred to the Ministry of Supply, and until 1945 he was a member of the Ministry's Chemical Inspectorate, working on chemical warfare problems.

Work with ARC

There followed a year with the Ministry of Supply's Flax Establishment in Norfolk, before appointment in 1946 to the staff of the Agricultural Research Council, where he worked on the development of insecticides and was Secretary of the Inter-departmental Insecticides Committees.

After four years with the ARC, Galley was seconded in 1951 to the Scientific Secretariat of the Office of the Lord President of the Council; this was at the request of Sir Henry Tizard who was at the time Chairman of the Advisory Council of Scientific Policy, on various committees of which Dr. Galley was to work for the next two years. In 1950 he was a founder member of a panel which in 1953 became the Pesticides Group of the Society of Chemical Industry; he was Chairman of this Group from 1954 to 1956.

In 1953, Dr. Galley joined the Colonial Office as Director of the Tropical Products Institute; last year the Institute was transferred from the Colonial Office to become part of the Department of Scientific and Industrial Research.



Climate and Control of Banana Leaf Spot

by **D. Price,** *Plant Pathologist,*
Cameroons Development Corporation.

The Cameroons Development Corporation was formed in 1947 by the amalgamation of old pre-war German properties that had been planted with oil palms, cacao, bananas, rubber and tea. Most of the estates grew more than one crop and these were frequently intercropped; this fact, coupled with the understandable neglect during the war years, made the task of planned economic agriculture after the war a formidable one. The majority of the estates are in the Victoria Division and, of approximately 50,000 acres being cropped, bananas were grown on about 20,000 acres during the period referred to in this article (1954-6.) The variety was without exception Gros Michel but because of the ravages of Panama disease (*Fusarium oxysporum* sp. *cubense* E. F. Smith) the task of selecting an alternative variety had begun in 1952.

Much has been written in recent years about the use of spray oils to control leaf spot disease on banana (*Mycosphaerella musicola.* R. Leach) although the actual mechanism of control is not, as yet, established. The elegant work carried out during the latter part of the 1920s by Knight, Chamberlin and Samuel (1) has served to show the care that must be exercised when using even highly refined oils in order to avoid reducing the yield of a crop.

There is definite evidence that the spraying of oils reduces the fruit weight of bananas, and this is especially likely during hot dry weather (3). On the Corporation's banana estates most of the acreage is sprayed aerially. Because of the expense of aerial application and the danger of reduced fruit weight, considerable thought has been given to planning individual estate spraying programmes.

Fruit Rejection

In many of the countries that are large exporters of bananas the disease pattern of leaf spot disease is modified by low minimum night temperatures which either prevent conidial production [i.e., asexual reproduction] or cause the non-viability of conidiospores. In the Cameroons, however, conidiospores appear to be less important than was the case several years ago and it is ascospore [sexual reproduction] infection that presents the greatest threat. If ascospore infection takes place on a banana that has just shot or is about to shoot, the effect on the fruit weight is very rapid, and this leads to rejection of fruit before shipping. There is always a certain proportion of rejected fruit at harvest on an estate due to careless harvesting, staining or bruising, but the level is usually low.

The graph in Figure 1 demonstrates the percentage rejection in one area during 1955 and 1956 where ascospore damage had been found in the Cameroons for the first time in 1955. It will be noted that the peak amounts of fruit rejected occur in May and September in both years. The amount of fruit rejected steadily increased and in 1957 the area was abandoned and replanted with rubber. The ever-increasing amount of Panama disease in the area made it uneconomic to control leaf spot disease by spraying.

The most important interpretation that can be placed upon the graph is not the increasing rejection nor the rapidity with which the estate became uneconomic, but the peak values occurring in May and September. The interpretation of this is that the fruit rejected in May took a little over 12 weeks to develop and that it was shot during February. The soil in this area cannot be considered a good soil for bananas and the leaf numbers averaged between seven and eight per mat, consequently the leaves that permitted the fruit development were produced during the period from October onwards, that is, during the late rains. Fruit produced later in the year tends to develop rather more quickly and the fruit rejected in September probably shot during June and the preceding leaves during the period from March onwards, i.e., during the early rains.

Effect of Climate

It has long been established that many of the diseases caused by ascomycetes are closely related to the climate and usually some climatic effect either permits the 'ripen-

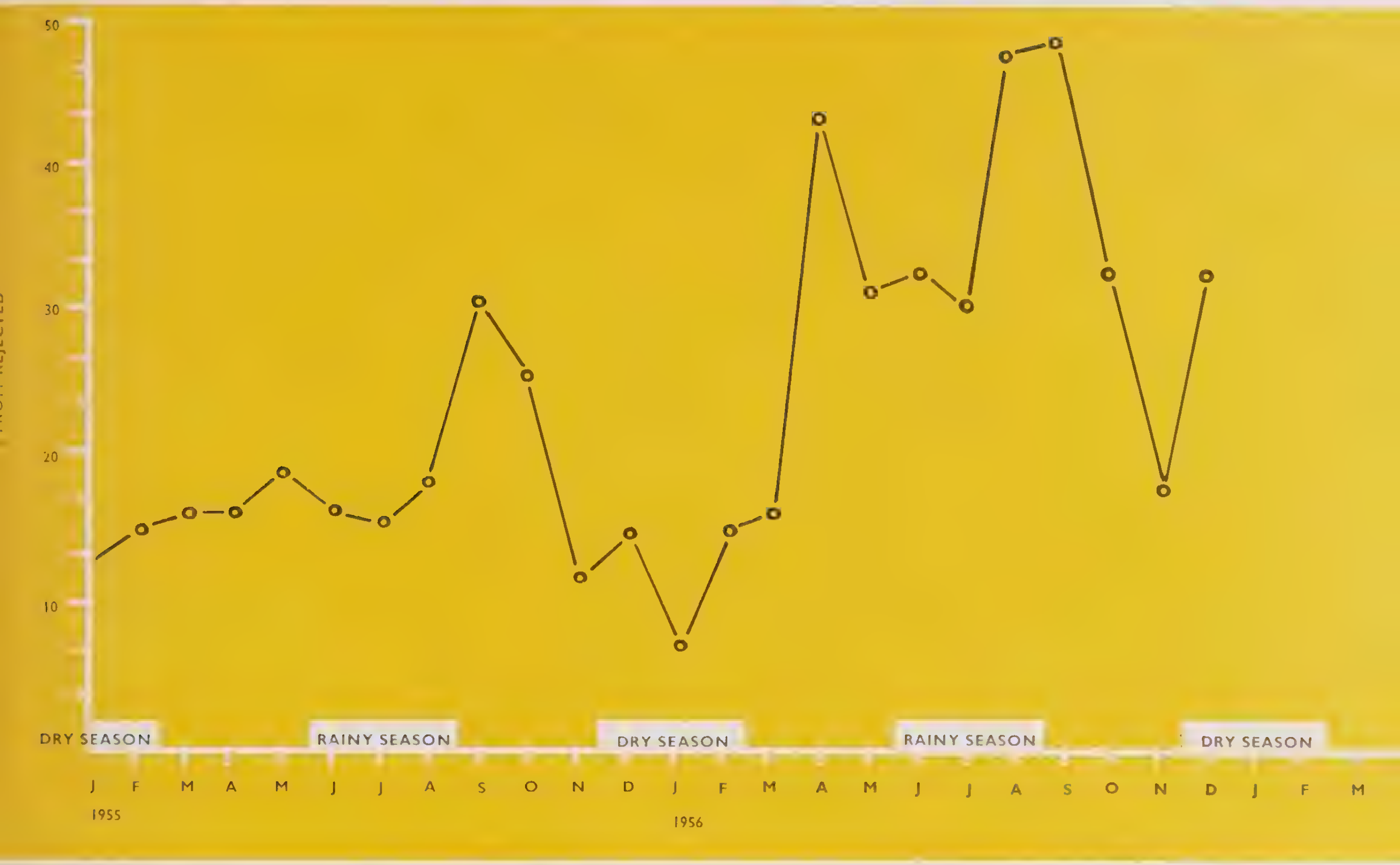


Fig. 1. This graph shows the fluctuating pattern of fruit rejection during 1955 and 1956.

ing' of sexual processes or actually sets off a mechanism of the ascus which releases the spores. A simple experiment served to demonstrate that in this case there is a 'triggering effect' caused by alternate wetting and drying.

Pieces of badly diseased leaf are more likely to contain perithecia than is lightly diseased leaf (2) and this material was either kept continually wet and inverted over plain agar, or wetted and after some hours dried and wetted again before replacing over plain agar. The leaf which was kept continually wet produced only one discharge of ascospores, whilst the same piece of leaf alternately dried and wetted produced 17 consecutive discharges, and the experiment was terminated not because ascospores were no longer detected but because the leaf disintegrated! It appeared that at room temperature (*circa* 80°F) the ascospores were released about five hours after wetting. After these facts had been learnt it was no longer surprising to see the increasing trend of fruit rejection in Figure 1.

It was now evident that the periods just before and just after the rains are dangerous from a disease control aspect because of the sunny periods and heavy rain showers, and before spray programmes could be planned it was necessary to consider this aspect in detail. The method chosen and later proved successful was the drawing of hythergraphs[1] from meteorological data recorded at each estate.

Use of Hythergraphs

The number of days with more than 0.2in. of rain are plotted against the number of days with more than one hour of sunshine for each month. These levels were chosen quite arbitrarily but represent approximately the amount of rain required to wet an old banana leaf and the amount of sun required to dry it. A hythergraph for the mean monthly values at Mbonge for 1955-8 is given in Figure 2. By comparing hythergraphs such as these with monthly observations on the amount of disease it is possible to draw up a spray programme with a considerable amount of confidence.

In the first instance inspection of the hythergraph suggests that there is little or no risk during the dry season at the top left-hand side of the graph because during the period December to April although there was much sun there was little rain; conversely, during August there was much rain but little sun. The critical periods for ascospore

[1]A hythergraph is a graph on which temperature is plotted against precipitation.

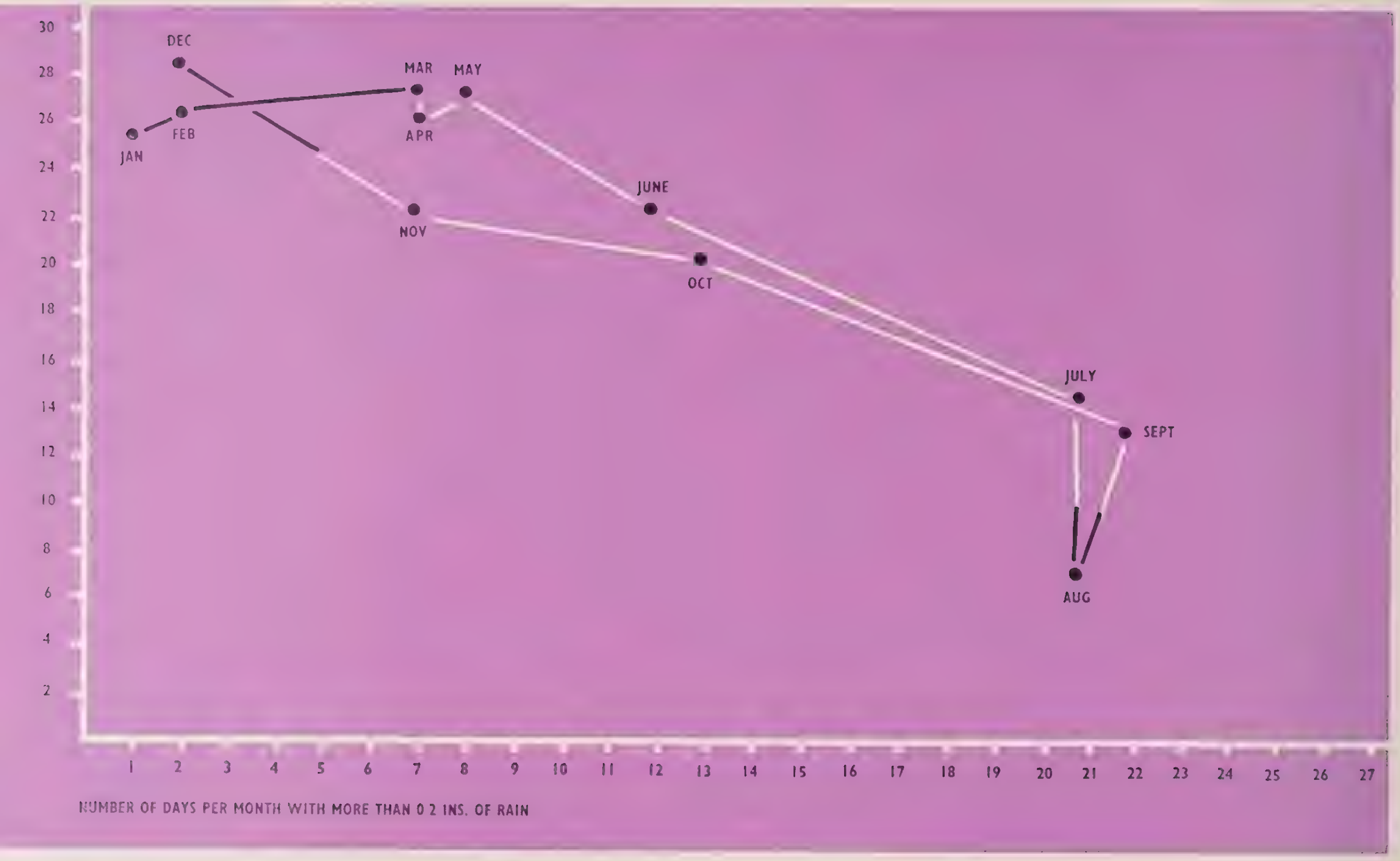


Fig. 2. This hythergraph shows rainy days and sunshine hours (mean monthly values for 1955-8) at Mbonge. Spraying is considered to be necessary during the periods indicated by white lines; it may safely be discontinued during the periods marked in black.

discharge are probably between four and eight weeks in advance of the peak values in Figure 1 (this allows for the time lag in spot development within the leaf).

A further safety factor had to be introduced before deciding in which month spraying was essential. This was because good coverage and a suitable level of oil deposit cannot be attained with one application, and experience had suggested that, although the fungistatic effects of oil are rapid, several cycles are required in advance of the first critical period of ascospore discharges before and after the heavy rains. The periods during which spraying is considered necessary are marked on the hythergraph in red, and those when spraying may safely cease in black.

One last point that requires emphasising is that when a decision to spray oil on bananas is taken, the viscosity and purity are the two vital factors, and the oil should be applied in minimal quantities. In the Southern Cameroons spraying is carried out, using a very pure naphthenic oil, from aircraft and ground machinery at fortnightly intervals at a rate of seven or eight pints per acre.

There is still much to be learnt about leaf spot disease, in particular about the mechanism of control by oil and the reason for the predominance of ascospores on some varieties; but generally speaking the use of oil has solved many problems and credit must go to Dr. Guyot and his fellow workers in Guadeloupe, who first introduced this method of control.

The author is grateful to the Cameroons Development Corporation for permission to publish this article.

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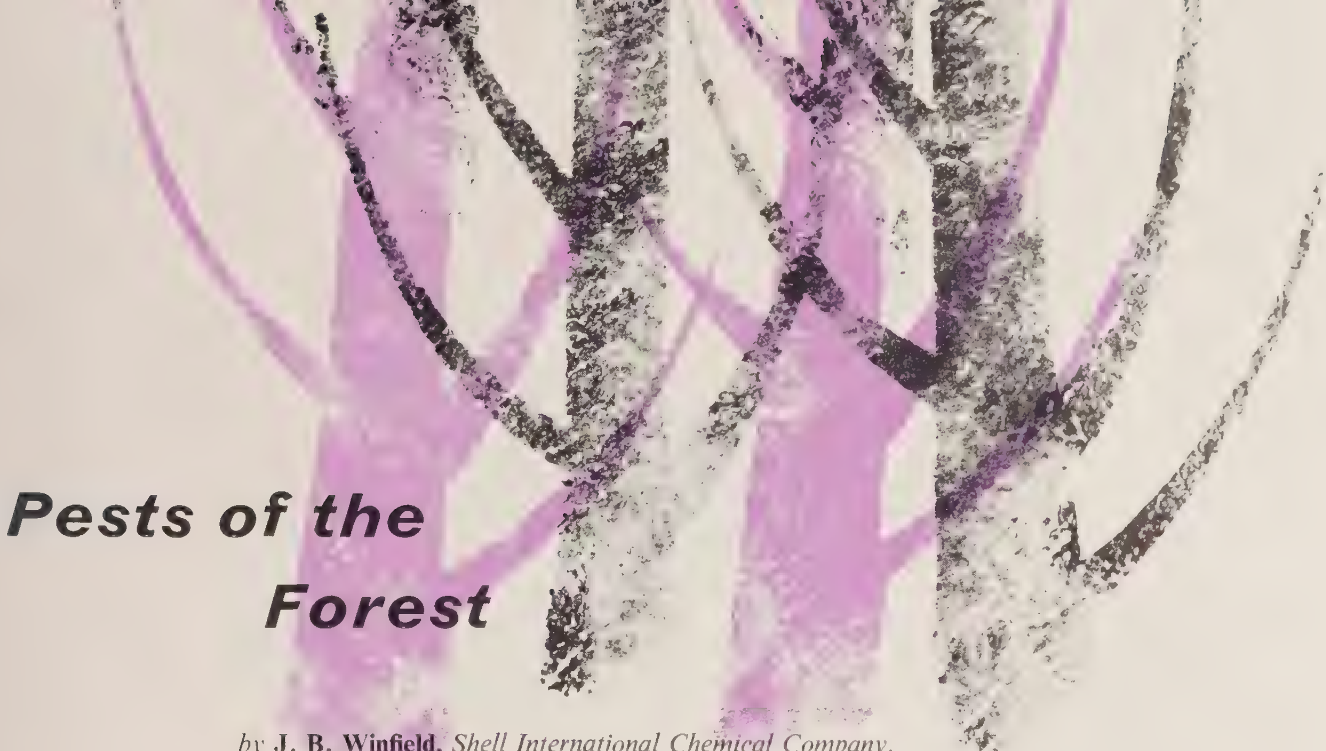
Table 1

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean no. rainy days	1	2	7	7	8	12	21	21	22	12	7	2
Mean no. hours of daily sunshine	25	26	27	28	22	14	7	13	30	22	22	28



Pests of the Forest

by **J. B. Winfield,** *Shell International Chemical Company.*

The bulk of forest pest control demands the use of the most advanced pesticide application machinery and of valuable aircraft, and the operations require a high degree of organisation. Therefore it is not surprising that practically all forest pest control is carried out by Government agencies who alone have the resources for the work. Yet air application costs are falling and forests can now be treated for less than a dollar per acre. Since interest in forestry is increasing, and more and more forests are approaching maturity and are consequently growing more susceptible to pests, it is logical to suppose that forest pest control will in the next decade become increasingly important in state forests, and perhaps will even spread to private plantations.

The damage caused by insect pests to forests in the USA alone is estimated at some $54m. per annum. This is equivalent to some 4½ billion board feet, the product of 52 million acres of forest, or 18 per cent. of the annual production. In addition to this direct destruction of timber, other serious losses are caused by insect attack.

Defoliators, for example, not only reduce the growth rate and curtail seed, bark and wood production, but make attacked trees more susceptible to damage by fire and by boring insects. Weevil attack may cause deformation of the wood, leading to wastage; and borers, besides causing direct destruction of part of the timber, lower the value of the remainder. The effect on individual trees is supported by the effect on the forest as a whole. Pest attack may lead to inadequate stocking and a consequent increased risk of fire, as well as deterioration due to weed growth, and may also produce conditions favourable to further pest build-up.

Defoliators are by far the most important insect pests attacking forest trees. They are often responsible for complete destruction of whole sections of the forest, though more often damage stops short of this and defoliation results in the slowing down of growth and curtailment of timber production.

The difficulties encountered in control of these pests in mature forests are considerably greater than those associated with the control of any other pest problem. First of all the terrain is often difficult, for natural forests remain chiefly on mountainous ground. Secondly, the areas are large and can often only be covered by aircraft.

Thirdly, since most pest insects are normally present in the forest in non-epidemic proportions, being kept under control by natural factors, it is difficult to detect a pest build-up which is likely to be troublesome. The vast areas involved complicate this, since inspection is difficult and expensive. Finally, due to the difficulty in detecting pest outbreaks, control measures usually have to be applied swiftly, since delay will result in considerable damage.

Use of Aircraft

These difficulties demand the use of aircraft, at first for regular surveys to look for pest outbreaks (defoliation can quite easily be spotted from the air), and then to carry out control measures effectively and speedily. Many types of aircraft are used for forest pest control, from small single-engined machines such as the Auster, Tiger Moth and Stearman, to large transport aircraft, such as the Boeing B17, and C82. Choice has largely been governed by availability, and war surplus aircraft have been used to a very large extent.

Large aircraft have the advantage of greater range and payload and can thus give speedier treatment at a greater

These young pine trees in Portugal have been defoliated by the processionary caterpillar, Thaumetopoea pinivora.

distance from base—an important consideration with defoliators. On the other hand, they require the use of a permanent airstrip affording a long take-off run, are more expensive to maintain, and are less manoeuvreable than smaller aircraft.

Possibly the best type of aircraft for forest work is the single or twin-engined machine of 450-600 h.p. such as the Beaver, Pioneer and Omnipol Brigadyr, with a payload capacity of some 200 gallons. These aircraft can use small temporary airstrips, and are manoeuvreable enough to obtain the best spray results with safety in practically all forest conditions. Helicopters have also been tried for forest pest control and are excellent for small areas and awkward terrain, but their high initial cost and high running costs discourage their use.

Very low application volumes are highly desirable in aerial operations since they considerably cut the time and cost of spraying. However, with small volumes atomisation must be very good to achieve effective coverage. The optimum size for spray droplets has been defined as 'the smallest that will reach the trees before evaporation', and this depends on conditions of temperature and humidity, as well as the distance they must fall and the volatility of the insecticide carrier.

Low volatile oils are favoured as carriers, especially diesel oil and gas oil which are readily available and which have suitable viscosity and solvent properties. The optimum droplet size for such carriers probably lies between 100 and 150 μ mass median diameter, though may be greater than this if the terrain or the forest is uneven. The droplet spectrum should not be too narrow, since drift by the smaller particles helps to extend the swath width and cover up inaccuracies in flying. Volumes as low as $\frac{1}{2}$-1gal. per acre are currently used, applied from boom and nozzle spray apparatus or other atomising devices such as the Micronair atomiser. These must be carefully calibrated and the nozzles so arranged that efficient distribution and atomisation are achieved *at the speed of spraying*.

Choice of Insecticide

The most widely used insecticide for forest pest control is DDT, and application of 1lb. of this insecticide in 1gal. diesel oil per acre is very nearly standard practice in the USA for control of defoliators. Cheap and of low toxicity, it is reasonably effective against most defoliators and has been used in campaigns against the gypsy moth, spruce budworm and nun moth, to mention only a few.

Endrin, also a long persistent chlorinated hydrocarbon, has been gaining in popularity for defoliator control and has been used against the gypsy moth, the pine processionary caterpillar, the oak leaf roller, the pine emperor moth and other pests at rates as low as 2oz. per acre. Toxaphene has also been used, notably for the control of wattle bagworm in South Africa, but has the disadvantage of being applied at 2lb. or more per acre. Dieldrin and BHC are also effective against some defoliators, notably Orthoptera.

Although aerial application is necessary under forest conditions, where trees are grown for ornamental purposes as in parks and along roadsides, or where the plantation is open, ground application machinery may be used. Low volume emulsion sprays are generally preferred, applied by mist blower, although in some places drift dusting is giving quite good results. Where the trees are tall, large machines of 25-30 h.p. must be used, delivering droplets of 30-80 μ mass median diameter in a blast of air of some 20,000-30,000cu.ft. per minute. These machines are expensive and are mounted on trucks or large trailers, and so their use is limited. Smaller mist blowers mounted directly

A Piper Cub equipped with spray boom, applying endrin in gas oil to oaks in Portugal for the control of Tortrix viridana.

Plasmids, Didymuria violescens, *have completely defoliated this alpine ash tree in Australia.*

on the tractor, or on small trailers, or carried on a stretcher or barrow, are effective enough for low growing trees such as oaks, and for young plantations, while knapsack mist blowers may also be used in some circumstances.

The most important forest pests are considered below.

Gypsy Moth, *Lymantria dispar* L.

Probably the most widespread of forest pests, this moth ranges throughout Europe and Asia between the 30° and 60° latitudes, and also occurs in the eastern United States, where it was introduced from Europe. There is one generation per year, the larvae hatch from the overwintering eggs in spring and feed for some two months on forest foliage. Infestation may exist for several years before it is noticed, being kept to an unimportant level by natural control factors before suddenly increasing to outbreak proportions; it may then cause complete defoliation in very large tracts of forest. Although one complete defoliation is not likely to kill most hardwoods it is fatal to conifers. Repeated defoliation reduces the vigour of hardwoods and they become susceptible to diseases and to secondary infestation by borers.

In the USA, between 1907 and 1957, $91m. of public funds were spent in efforts to eliminate the gypsy moth; the annual rate of expenditure has since been increased and, for example, in 1957 three million acres were sprayed with DDT against the moth.

In Europe the gypsy moth is important in many countries, especially on oaks, and campaigns against it using DDT or endrin are regularly undertaken. In Portugal the insect is virtually under control after 10 years of chemical control operations.

Spruce budworm, *Choristoneura fumiferana* (Clem.)

Spread throughout the whole range of its host plant, spruce budworm is particularly important in the United States, where 1,500,000 acres were treated against it in 1957. The larvae hatching in the spring from overwintering eggs first tunnel into old needles, then bore into the opening buds, and subsequently make a 'nest' by tying together the tips of several twigs. The larvae feed now on the new growth, chewing through the needles near to the stem and destroying far more than they actually eat. Control is obtained with 1lb. DDT per acre in 1gal. diesel oil, sprayed from the air.

Pine Processionary Caterpillar, *Thaumetopoea pityocampa* Schiff.

Particularly important in Europe, *Thaumetopea pityocampa* is a pest of pines, especially in the Mediterranean region. The caterpillars emerge in late summer and are gregarious, building a 'nest' by spinning silken webs. They eat the foliage, moving progressively higher up the tree. Control is best begun early since the larvae feed very rapidly, and are to some extent protected by the nests. Endrin has proved extremely effective against this pest and is widely used in Spain, applied from the air or from knapsack sprayers or mist blowers at 20-24 litres of a one per cent. water emulsion per hectare.

Oak Leaf Roller, *Tortrix viridana* L.

Oak leaf roller is one of the most important pests throughout Europe. The larvae begin attacking the foliage in early summer and on deciduous oaks defoliation may start before the leaves are properly freed from the buds. The edges of the leaves are turned under or rolled and thus afford some protection to the larvae. On deciduous oaks the tree may be completely stripped early in the summer and a second crop of leaves may be produced before the end of the

season; this damage causes considerable reduction in seed and bark production and in timber growth. Control with persistent insecticides must begin before the new foliage is fully developed and some 20-30 days after the first eggs hatch. DDT and endrin have been widely used in Europe, sprayed from ground machinery or from the air, or applied with the drift dusting technique.

Pine Emperor Moth, *Nudarelia cytheria capensis* Stoll.

In South Africa the pine emperor moth is a danger to the considerable plantations of *Pinus radiata*. Commercial control with chemicals began only in 1955 and before this the pest was kept fairly well under control by pigs, both domestic and wild, which roam through the woods and which root out and destroy the pupae in the soil.

Endrin at 2oz. active material per acre in 3gal. diesel oil gives good control.

Wattle Bagworm, *Acanthopsyche judoni* Heyl.

The larvae of the wattle bagworm hatch in the spring and feed on the foliage of the wattle plantations, each preparing a 'bag' of leaves hanging from the branches of the tree. These bags, as well as being a sure sign of infestation, afford considerable protection to the larvae. Control is obtained with aerial sprays of Toxaphene at 2-3lb. per acre, or endrin at 2oz. per acre in solution in diesel oil, the latter insecticide giving better results against later larval instars.

Phasmid, *Didymuria violescens* Leach

The phasmid is a pest of eucalyptus, the major tree species in Australia, and is generally of sporadic importance. But in the Alpine Ash forests of New South Wales it has been troublesome every other year since 1952. Alpine Ash does not recover from complete defoliation and many trees have been killed by phasmid attack, whilst to many others partial defoliation has meant a curtailed growth rate. The value of the forest destroyed is indicated by the annual increment which is worth £4 10s. per acre. Control operations have been based on BHC or dieldrin applied from the air in 1-2.5gal. oil per acre.

Sawflies, *Neopridion sertifer*, *N. pinetum*, *N. lecontei*, *N. erichsonii*, etc.

The sawfly larvae, hatching in the spring, are gregarious and cause severe defoliation to a very large range of conifer species including pines, larch and spruce. Outbreaks of the pests have been controlled in Europe by DDT sprays.

Pine Shoot Moth, *Evetria* (*Rhyacionia*) *buoliana* (Schiff.)

After first boring into the old needles, the larvae of the pine shoot moth attack the leading shoots of pines and destroy the buds, producing pitch galls, malformation and retardation of growth. Thus the pest is more important in the nursery and in young plantations, where it is sometimes controlled by DDT sprays in Europe; recent experiments in the USA, however, indicate that systemic insecticides such as Phosdrin or Systox give better results.

While the defoliators discussed above pose the most important control problems, certain other forest pests also must be controlled. In the forest nursery conditions are favourable for many insect pests. In the soil, white grubs (*Melolontha* larvae) are most important and through their feeding on roots can completely prevent the establishment of new plantations. They can be well controlled, however, by soil applications of aldrin or BHC—as can other soil insects such as root borers and wireworms. Above ground, girdling insects such as weevils, e.g., *Pissodes* and *Hylobius* spp., which by ring barking cause the death of many young trees, can be controlled by spraying the point of expected attack with dieldrin or DDT, while foliage pests may be controlled by general DDT or endrin sprays.

Aphids and other sap suckers may be important too, in the nursery (because of the greater susceptibility of the young trees) but can be controlled by phosphorus insecticides—or better, by systemics. Application of the pesticide is no problem in the nursery and knapsack or tractor-mounted sprayers and mist blowers are widely used.

Finally, control measures may be taken against the boring insect. Beetles, such as *Ips*, *Dendroctonus* and *Scolytus* spp. etch extensive galleries beneath the bark, and in the early stages may be controlled by the application of fumigants such as dichlorbenzene, or of volatile insecticides, and 1-1½lb. BHC per tree is often used in the USA. Frequently, infestation can only be controlled by felling and removing the infested tree.

The lepidopterous borers, such as *Cossus* and *Zeuzera* spp. pose more of a problem in the young plantation or nursery, where affected trees must be felled and burned. When it is particularly important that a tree should be preserved extensive surgery is often necessary. The control of borers demands the treatment of individual trees and thus is virtually confined to trees grown for ornamental purposes.

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The Root-Knot Nematode in Central Africa

by **George C. Martin,** *Senior Helminthologist, Ministry of Agriculture, Central African Federation.*

A high percentage of the known genera of plant parasitic nematodes is represented in the Federation of Rhodesia and Nyasaland—in many instances by species which are likely to prove new to science.

Due no doubt to the obvious and easily recognisable galling arising from heavy attacks by the *Meloidogyne* spp., or root-knot nematodes, and also to the fact that tobacco, by far the most valuable export crop in the Federation, is extremely susceptible to attack, almost all nematode investigational work in the Federation has been restricted to the *Meloidogyne* spp. Thousands of examinations of roots of plants from many parts of the Federation have revealed that four of the known species of *Meloidogyne* are present and that one of these, *M. javanica* (Treub 1885), Chitwood 1949, is so widely distributed that almost without exception it is encountered wherever host plants are cultivated.

A considerable number of records exists of *M. javanica* infections appearing in crops grown on apparently virgin land. The term 'virgin land' is generally accepted in the Federation as descriptive of any area for which there is no history or evidence of cultivation. The other species of root-knot nematode so far encountered are *M. hapla* Chitwood, 1949, *M. arenaria* Chitwood, 1949, and *M. incognita* var. *acrita* Chitwood, 1949; these are commonly found in commercial nurseries, flower and vegetable gardens, and to a lesser extent in market gardens and farm irrigation schemes. It has become evident that unless there is a history of cropping which has included vegetative propagation, only *M. javanica* can be found: no exception to this has as yet been demonstrated.

History of Root-knot

The earliest known record of root-knot in the Federation is an infection on potatoes—there exists a museum specimen of an infected tuber dated 1910; the species of nematode involved is now known to be *M. javanica*. In 1912 the *Rhodesia Agricultural Journal* (1) reported that root-knot nematodes were apparently unknown on tobacco farms; the following year JACK (3) noted that 'complaints of injury have been increasingly frequent of late' but that 'the great bulk of farms are at present free'.

By 1920 it was being noted that root-knot nematode was on the increase, probably due to spread by the use of infected potato seed. At this time, JACK (4) wrote that tobacco fields were generally free from this pest but by 1927 he had reported considerable trouble being experienced in the seedbeds and fields. The same year, HOPKINS (2) noted that root-knot nematodes appeared to be well distributed throughout Southern Rhodesia and were likely to become one of the most serious menaces

Left, *a tobacco plant root badly infested with root-knot nematode;* right, *this healthy root has grown in soil fumigated with D-D.*

to tobacco growing. Seven years later unusually severe infections were reported by tobacco growers (JACK [6]) and the following year root-knot nematodes were considered one of the most serious pests affecting tobacco (JACK [7]).

From this time onwards more attention was paid to these nematodes. Investigations showed that the rivers running through the tobacco growing areas were generally infested by wash from fields during heavy rains, causing the spread of flood waters over the banks and adjacent areas; with the recession of these waters, root-knot nematodes were left behind infesting the soil. Moreover, most seedbed areas were sited during the dry season on river banks, and water from the rivers was used for irrigation. Further work revealed that very many of the indigenous plants were capable of acting as hosts to root-knot nematodes.

Soil Fumigation

It was not until 1946, with the introduction of Shell D-D[1] Soil Fumigant and ethylene dibromide into Southern Rhodesia, that any real progress was made on the chemical control aspect of the nematode problem. At that time, the difference in price between D-D and ethylene dibromide precluded the use of the latter. The almost total eradication of root-knot nematodes from seedbed sites by the application of 50-60gal. D-D per acre, coupled with the startling results achieved by D-D fumigation in the fields, led to these measures being rapidly adopted by tobacco planters.

Coinciding with the adoption of soil fumigation, great progress was made in the construction of dams and the sinking of boreholes, thus enabling tobacco planters to site their seedbed areas away from infested river banks, and thereby to reduce the risk of introduction of root-knot nematodes in the irrigation water. The availability in 1950 of ethylene dibromide in high concentration at an economic price, led to the first commercial importation of this chemical for the control of root-knot nematodes by soil fumigation, and today it appears to be more widely used than D-D.

Experiments (MARTIN [8]) were carried out during the 1949-50 season, using methyl bromide for the control of root-knot nematodes and weeds in tobacco seedbeds, and during the succeeding years this chemical slowly gained favour for these purposes. It was not, however, until 1957 that methyl bromide became popular, and since then it has leapt to the fore and shows every sign of supplanting other chemicals for tobacco seedbed fumigation. The reason for the recent popularity of methyl bromide is no doubt associated with the greatly increased

[1]D-D is a Shell trade mark.

An experiment in Rhodesia. In the centre are five untreated rows of tobacco suffering from nematode infestation; on the extreme left and right is healthy tobacco growing in soil which has been treated with D-D.

distribution of anthracnose, a disease of tobacco which can, in the seedbed soil, be controlled by this chemical.

Cost of Nematode Damage to Tobacco

No investigations into the economics of root-knot nematodes in relation to tobacco have ever been carried out, but that these nematodes are of considerable importance cannot be questioned; a few years ago, losses in tobacco crops due to root-knot nematodes were considered to amount annually to well over £1,000,000, though this must be regarded at best as an informed guess.

To obtain reliable indicative figures on the economic significance of root-knot nematode infections of tobacco, the sale of soil fumigants to tobacco planters for the 1958-59 season was investigated. It was found that of a total of 216,000 acres of tobacco grown, approximately 42,500 acres (about 20 per cent.) were treated with either D-D or ethylene dibromide. When it is considered that most growers only fumigate fields which are known to carry such high soil populations of *M. javanica* that crop loss will result without treatment, the seriousness of the problem can well be visualised.

It is fortunate that tobacco, grown under conditions prevailing in the Federation, appears to tolerate a relatively high root-knot nematode burden without serious results, provided that the attack is not initially heavy and that the transplants can become established without enduring a serious setback. It is because of this tolerance that fumigation of the ridges or planting positions is so successful. The treatments provide conditions, even in heavily infested soil, which enable transplants to become established in nematode-free zones or ridges, and it is not until the later stages of growth that root-knot nematodes from outside the treated zones can infect the plants.

By the end of the growing season it is usual, in heavily infested but row-treated fields, to find the root systems of the tobacco plants heavily galled by root-knot nematode attack. When set in heavily infested untreated fields transplants usually remain small and stunted or die before marketable leaves are produced. If they are set in treated rows in heavily infested fields and receive an early severe check to growth due to drought conditions, root-knot nematodes are likely to invade the roots in such numbers that the plants are unable to make good growth when rain does come, and reduced yields result.

Seedbeds

Precise figures of the acreages of seedbeds planted during any one season are not known, but a reasonable estimate is of one conventional sized (75ft. by 4ft.) bed for each acre of field planting, with approximately 72 such beds to an acre of land. Such calculations result in a figure of

approximately 3,000 acres of seedbed sites planted for the 1958-59 crop of 216,000 acres of field tobacco; if this is correct, then 1,800 acres (60 per cent.) were treated with soil fumigants. Whilst this figure is high, it is a matter for some concern that so many acres of seedbed sites remain untreated. It is considered that as a precautionary measure, all seedbed sites should be fumigated annually.

The reasons for the comparatively rapid build up of *M. javanica* in the old and established tobacco areas become apparent when the following facts are considered: before 1947 most seedbed sites were situated on or close to infested river banks; river water was used for irrigation; no effective chemical control methods were used in the fields or seedbeds; tobacco was grown in the fields for two and often three consecutive years, and when such fields were 'rested' they were allowed to revert back to 'bush', the flora of which usually contained many good host plants.

Today the picture is quite different: seedbed sites are usually well away from the rivers; borehole or dam water is used for irrigation purposes; high percentages of seedbed sites and infested fields are chemically treated; and tobacco is not grown more than once in a four- or five-year rotation which includes a ley, for three or four years, of *M. javanica*-resistant grasses such as Weeping Love (*Eragrostis curvula* var. Ermelo) or Katambora Rhodes (*Chloris gayana*).

Wattle

The black wattle tree, *Acacia mollissima*, is grown extensively in the eastern highlands of Southern Rhodesia for tannin, which is extracted from the bark. A survey of root-knot nematode infection on black wattle, which is currently in progress, has so far revealed isolated infections by *M. arenaria*, and has also revealed that *M. javanica* is widely distributed throughout the area—but obvious damage has only occurred in one or two small areas, to seedling trees of the first redevelopment scheme (second crop).

As the economics of wattle growing are linked with mono-culture it would appear only a matter of time before *M. javanica* becomes a very real problem. Fortunately, the black wattle tree is an extremely prolific root producer and soil infestations of the root-knot nematode are markedly 'patchy', thus usually a low percentage of the roots of any one tree is infected.

The bulk of the wattle plantations are situated on virgin hillsides and the industry is in its infancy, one crop only having been gathered from any one plantation. The extensive although patchy distribution and, in numerous instances, the high level of infection of *M. javanica*, provide, therefore, much food for thought.

Other Crops Attacked by Root-Knot

Potatoes, clovers, lucernes and peas have all been seriously attacked by *Meloidogyne* spp.

Potatoes. It is accepted by many growers, although no investigational work has been carried out, that a potato crop grown under irrigation in the cool dry season, on land heavily infested with root-knot nematodes, will have but a small proportion of the tubers 'blistered' by the parasites, whereas a crop produced on heavily infested land in the hot wet season will undoubtedly be almost unsaleable. Very few areas, suitable for seed potato production and not infested by *Meloidogyne* spp., have been found and therefore a tolerance of 1 per cent. root-knot nematode infection, assessed by the blistering of tubers, is permitted for Federation grade A 2 seed, which at present is the best locally produced seed available in quantity.

Clover. A number of instances of clovers dying out of mixed grass leys has been recorded, and a screening programme of pasture legumes exposed to high soil populations of *M. javanica* is now in progress.

Lucerne. Heavily infected mature lucerne plants have not yet been recorded in the Federation, but severe stunting and dying-off of seedling plants, due to attack by *M. javanica* have been observed.

Peas. Many cases of total crop loss or serious yield reductions have been recorded for irrigated pea crops, due to attack by all four of the *Meloidogyne* spp. found in the Federation.

Grape; paw paw (papaya); banana. Examinations of roots of grape vines, paw paw and banana trees have shown that many are infected with root-knot nematodes, but no information is available concerning the possible effect on yields.

Citrus

Unthrifty citrus trees have been found to be heavily infected with the citrus nematode, *Tylenchulus semipenetrans*, but it is not known whether the poor growth is entirely due to nematode attack.

The reader will doubtless gather that most of the effort of the Federation's nematology section is at present concerned with the *Meloidogyne* spp., their distribution, host ranges and screening trials, and also with general advisory work and investigations on control measures by crop rotations and the use of soil chemical treatments. Until many more plant nematologists are engaged on investigational work and producing the mass of urgently required information, progress will of necessity be slow.

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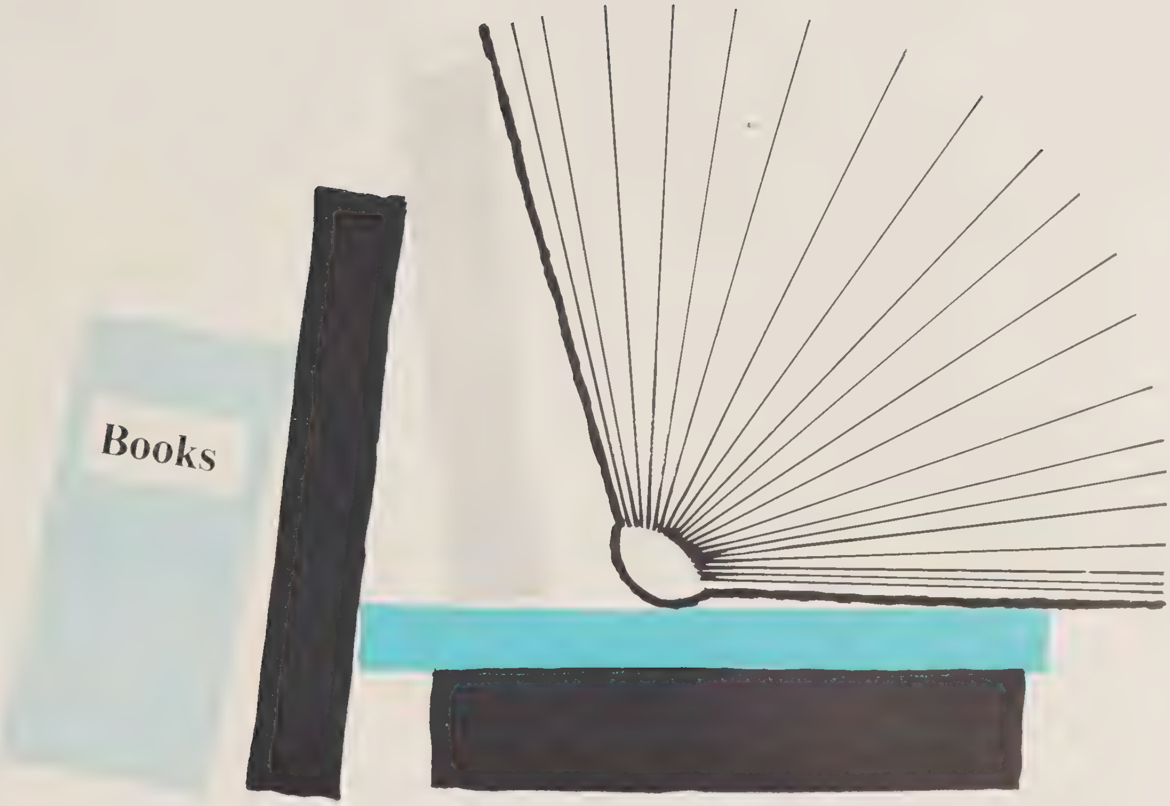

The Measurement of Grassland Productivity. Proceedings of the University of Nottingham Sixth Easter School in Agricultural Science, 1959. Edited by J. D. Ivins. Butterworth, London. 35s.

This is not a farmers' book, for it has been mainly written by scientists for scientists, but nevertheless there is a great deal in it which will be of interest and value to the progressive grassland farmer. Despite the fact that there are 19 contributors, each with his different style and approach to his segment of the total problem, it is a very readable and logically arranged book. The credit for this belongs to Professor Ivins, who has done a first-class job in assembling the individual contributions from men from several countries into a coherent whole. In my opinion, it is one of the best student books on grassland that have come out for a very long time.

Dr. William Davies, in the opening chapter, traces the evolution of techniques of measuring grassland productivity. It comes as a shock to read that, apart from Somerville's early work at Cockle Park, the use of the animal for measuring grassland productivity is essentially a modern development. Most workers have contented themselves with some form of cutting technique complemented by chemical analyses to establish relative yields of nutrient pastures. It has long been realised that this is unsatisfactory, but subsequent chapters help to explain why grassland workers have had to rely on this approach.

Leaving aside expense of fencing, water supplies and land in order to make direct use of the grazing animal, there are the seasonal changes that take place in both the quality and quantity of available pasture. Then there is the complication of rates of stocking, because these in themselves will influence productivity, and so will the system of stocking that is adopted. For instance, in Somerville's original experiment on Treefield, the uniform rate of set stocking on nine of the 10 treatments meant that live-weight production on each of these treatments showed no appreciable difference. The animals on each plot had a certain capacity to grow, and they expressed this capacity because there was sufficient feed for them to do so. If a higher rate of stocking had been adopted then differences in productivity between treatments might have been revealed. Quite clearly, rate of stocking has to be a variable in experiments where grassland productivity is being measured through the animal.

The next complication comes in interpreting the live-weight or milk yield data that have been obtained. Apart from inherent differences between individual animals in their capacities to grow or produce milk, they also vary within themselves according to stage of growth or stage of lactation.

It is not surprising, therefore, that no simple satisfactory method of measuring pasture productivity has yet been evolved. In this respect grass suffers in comparison with crops like cereals where there is a definite and easily measured end product. This is the reason why it is so difficult for any grassland adviser to give definite recommendations as to species, varieties, or fertiliser rates. Yet as one goes through the book there comes a feeling that there is some sort of order coming out of chaos. The work of Raymond at Hurley and Ivins at Nottingham is bringing us nearer to the goal; one doubts, however, that it will

ever be possible to assess a pasture accurately in terms of utilised starch equivalent per acre.

Finally, a few words must be written about the last chapter by Mr. Rex Paterson, who is the one farmer contributor. Apart from the material it contains, it also provides a valuable lesson. The intelligent keeping and analysis of records by a farmer can produce dividends in the shape of a more enlightened management policy for grassland. This is the secret of Mr. Paterson's progress as a grassland farmer. The lessons he has learned are of much more than personal value. He has added very materially to our knowledge of how to get the most out of our pastures.

M. McG. Cooper.

An Introduction to Animal Husbandry in the Tropics. G. Williamson and W. J. A. Payne. Longmans, London. 48s.

Mr. Williamson is a veterinarian who has spent much of his life in the tropics or sub-tropics, and especially in India. Dr. Payne is at present Head of the Division of Animal Husbandry in Kenya, but he has travelled widely and has had first-hand experience of live-stock farming in a large number of tropical countries. The two have made an excellent team, for there is the sort of blend of veterinary and husbandry aspects that is necessary in a book dealing with tropical livestock production in which disease is so often the factor that sets the limit of livestock performance.

The book is one of a series on tropical agriculture which is being published with active encouragement from the Colonial Advisory Council of Agriculture, Animal Health and Forestry. Along with other books in the series, it will fill a long felt need for authoritative literature on tropical farming. Apart from Britons who are preparing themselves for the Colonial Agricultural Service, there is a growing body of native students in departments of agriculture of the new universities in Africa, Malaya and the West Indies, which have developed under the scheme of special relationships with the University of London. These men have had to suffer through a paucity of books which deal specifically with their conditions, and have had to rely on lecture notes to much too great a degree.

One of the most urgent tasks facing the emergent countries of the Commonwealth is a stepping up of agricultural production, and the need for an increased number of trained men is very great. Especially is this true in respect of the production of milk, meat and eggs, which are in such short supply in many of these countries. This book will be especially valuable to these students.

There is a logical sequence from basic principles relating to environmental effects, disease control, nutrition and breeding, through to husbandry of the several species of domesticated animals and then on to animal products. The chapter on the effects of climatic conditions on livestock performance is a particularly good one, for this is very much in Dr. Payne's own field of work. The chapter on breeding is possibly the most disappointing, in that it is rather old fashioned in the sense that it gives very little attention to modern concepts of population genetics. Fortunately there are now a number of very good books on the subject which deal adequately with fundamental aspects of breeding.

One must not make too much of this criticism, for it is not possible to put more than a quart into a quart pot, and this particular measure is very full. There is, of course, much more variety than one encounters in a book on temperate animal husbandry which has no concern with such species as the camel and the buffalo. The authors, recognising the impossibility of being authoritative over a very wide field, have wisely brought in collaborators to write certain chapters. It is a tribute to the editing that there is such a uniformity of literary style. Perhaps the most interesting of all these contributions is an appendix on the African nomad, written by C. J. Hanson-Smith, which makes really fascinating reading and gives one an insight into the magnitude of the problems, both animal and human, facing those who hope to improve livestock in Africa.

Altogether this is an excellent book, and it deserves a place on the bookshelf of anyone concerned with tropical livestock production.

M. McG. Cooper.

Scientific Principles of Feeding Farm Livestock. Farmer and Stock-Breeder Publications, London. 50s.

This book, published last year, comprises the proceedings of a conference held in 1958 to assess the state of knowledge concerning nutrient allowances and margins of safety for farm livestock in the United Kingdom in relation to reproduction, growth, and production of meat, milk, wool and eggs.

Divided into sections on dairy cows, ruminants other than dairy cows (calves, beef cattle and sheep), pigs and poultry, the book provides thoroughly up-to-date information on the principles of feeding farm livestock, and forms a useful work of reference on the subject.

Principles for British Agricultural Policy. Edited by H. T. Williams. Oxford University Press, for the Nuffield Foundation. 18s.

A great deal has been written about policies for British Agriculture, a subject which is too often pursued with little or no objectivity, arguments being pressed on inadequate data and often from conflicting premises.

The study recently published for the Nuffield Foundation is greatly to be welcomed as much for the interesting way in which the problem has been approached as for the careful manner in which the relevant facts have been marshalled and the conclusions drawn therefrom. The purpose of this study 'was not to advocate policy, for policy is the responsibility of government; it was to adduce a body of principles on which long-term policy might be based . . .' It was started at the end of the war in a period of still acute shortages of food; through unforeseen circumstances it has only just been completed in the present period of market plenty. In effect the survey has gained much more than it could have lost by spanning nearly a decade and a half, a period which has witnessed such a remarkable technical development of British agriculture as it has passed from the stringencies of a closely controlled war-time economy to the freedom of its present position under price guarantees and subsidies.

The survey, which was initially a committee effort under the chairmanship of Sir Frank Engledow, broke up the problem into its components: it has reviewed the problems presented in the making of a sound national agricultural policy from diverse angles; from the historical angle, from the point of view of the technological efficiency of the industry, from the sociological angle and from the overriding strategic considerations. The most fascinating part of the whole survey is that whereas it might almost have been expected that the conclusions to each section would have been in conflict one with another, in fact they have all led not as much to conflict or compromise as to common conclusions.

The study demonstrates that the principle for permanently maintaining an agricultural industry at a level higher than can

be economically justifiable rests largely on the strategic argument; that from a technical point of view it is potentially capable of substantial further increase in productivity, but that there are relatively few sociological or nutritional arguments to be deduced either in favour of or against such a policy. No attempt has been made to judge whether the present level of production is above, at, or below the level that strategy seems to require.

The common theme running through all the sections of the report, however, is that what really matters from a national point of view is not so much the present level of output as the potential output of the industry—its flexibility to meet changing circumstances whether they be induced by sudden strategic demands or by less dramatic but no less fundamentally important changes in the national economy. The strength of our agricultural economy, it is with much justification affirmed, is primarily dependent upon being based upon mixed (but not muddled) ley farming which alone can give to it its all-essential flexibility, whether for peace or war. Perhaps even greater emphasis might have been given to the need for the flexibility of the minds of those responsible for the farming of the land than to the nature of the farming system, for the greater includes the less. The full potential of our agriculture depends ultimately even more upon the competence and flexibility of our farmers and their advisers than it does on the land itself.

The report represents a most valuable contribution to the very complicated field of agricultural policy making and, although specifically dealing with the difficulties and peculiarities of the British problem, it is a survey which must be studied most carefully by all those who are concerned with such matters in other lands, for basically the problems with which it deals are common to any social economy. DUNSTAN SKILBECK.

Farm Rents. D. R. DENMAN and W. F. STEWART. Allen & Unwin, London. 27s. 6d.

One of the most striking features of post-war agriculture in Great Britain has been the extent to which the increase in rents on tenanted farms has lagged behind the increases in other farm expenditures, as well as in farm product prices and farming profits. In 1955, a Committee representing landowners, farmers, professional institutions and the Ministry of Agriculture was set up with a view to promoting a thorough investigation into all aspects of farm rents in England and Wales. The conduct of the enquiry was entrusted to the Department of Estate Management of Cambridge University and this book is a report on the results obtained by the two responsible members of that Department.

Information was collected, chiefly by means of a comprehensive questionnaire, from 12,660 rented farms, covering 32 per cent. of the rented farms of not less than 15 acres in size, chiefly for the years 1945 to 1957. It was found that the average rent was 38s. 5d. an acre in 1957, compared with 23s. 5d. in 1945 and 21s. in 1936/7. Although strict comparison is not possible, because of the difference in the sample, the report shows that between 1937/8 and 1956/7 net farm income rose by 461 per cent. against only 83 per cent. for farm rents, so that the comparatively small increase in farm rents cannot be attributed to the farmer's inability to pay higher rents.

This investigation was, however, unique in so far as it throws much new light upon the causes of rent variations, from year to year, from district to district and from one estate to another. It shows that rents are influenced not only by the size of the farm, the quality of the land, the situation and so on, but also by the way in which the rent is determined: by negotiation between landowner and sitting tenant, by open-market competition or by arbitration. It also shows that the nature of the fixed equipment provided by the landowner is an important element in the rent. The thoroughness with which the causes of rent variations are explored may be judged from the fact that no fewer than 51 analytical tables and nine diagrams are presented and discussed.

The authors make the important point that the report is 'no more than a factual statement of findings', and although their desire for complete impartiality can be appreciated readers would probably have welcomed the leavening of the hard tack of facts and figures with occasional discussions of the social, economic and political implications of the findings. As things are, the book makes rather heavy reading and indeed calls for concentrated effort and study.

Nevertheless, within their self-imposed framework, the authors are to be heartily congratulated on the production of a report of outstanding merit, a report which will for many years to come be regarded as a standard work on the subject of farm rents.

The book has no index but the contents of each chapter are given in considerable detail. There is a useful glossary of terms used in the text. JAMES WYLLIE.

Antibiotics: Their Chemistry and Non-Medical Uses. Edited by H. S. GOLDBERG. van Nostrand, Princeton, N.J. $15.

While the use of antibiotics in medicine has become an accepted part of our life, the wealth of work since the war on other applications has received little publicity. The results have certainly been less spectacular and few commercially acceptable products have emerged. However, antibiotics undoubtedly hold considerable promise, particularly as dietary supplements, systemic fungicides and food preservatives. There is therefore an outstanding need for the collation of all the available information.

This book is primarily a work of reference and, treated as such, will prove invaluable to all interested in the subject. It suffers, however, from a certain lack of balance, particularly evident in the introduction. The history and mode of action of antibiotics are well outlined; less so, what is known of the mechanism of resistance, while the section on economic aspects is so inadequate as hardly to merit inclusion.

The chapter which follows (contributed by the co-discoverer of oxytetracycline) on the chemistry of the various groups of antibiotics, is detailed, authoritative and up to date.

The contribution on antibiotics as food additives is one of two chapters of particular interest to the agriculturalist. As the author points out, it is clear that growth stimulation is not due to any single factor. One comment (referring to effect on intestinal flora)—'It is apparent that conflicting data are absent only when there is no more than one report on the topic'—is well worth quoting as applicable to a great deal of scientific investigation in its infancy. The author highlights, however, the little understood but extremely interesting phenomenon of 'hormoligosis'—the direct stimulation of living tissues by very small quantities of certain substances—and postulates that this effect will prove to be much more widespread than is generally appreciated.

The chapter on disease control may be disappointing to the reader in the little space given to the results of trials on the control of plant pathogens. However, a most useful summary is given in tabular form, with adequate reference to the litera-

ture. A general account is given of the various methods of application, the stability and persistence of antibiotics and their compatibility with other pesticides. Methods of bioassay and their validity are dealt with in considerable detail, as are the effects of various additives to improve the rate of absorption of antibiotic formulations. Systemic activity, a major advantage of antibiotics, is itself discussed later in the chapter. Phytotoxicity of antibiotics is reviewed and finally the considerable amount of work on their mode of action and the problem of resistance, although the latter has yet to be conclusively demonstrated in the field.

An interesting chapter summarises the use of antibiotics in food preservation where their main role will be to supplement conventional methods. There is ample evidence to show the economic benefits, but legislation governing this application is likely to remain strict.

After a short chapter on the use of antibiotics in the isolation and cultivation of plant and animal pathogens, by eliminating bacterial and mould contaminants, the final chapter deals in detail with the public health aspects hinted at by earlier contributors. Here the author emphasises that medical dosages are many times greater than residues likely to be present in treated foods and that effects produced by intramuscular and intravenous injection cannot be used as evidence of the hazards involved by direct contact or ingestion.

The whole book provides a comprehensive and up-to-date review of the available literature which will undoubtedly prove of great value and general interest. Mention should be made of the list of some two thousand references which have been summarised in the text. I. D. FARQUHARSON.

Food: U.S.D.A. Yearbook of Agriculture, 1959. Edited by A. STAFFERUD. The United States Department of Agriculture, Washington, DC. $2.25.

The United States Department of Agriculture have chosen 'Food' as the subject for their 1959 *Yearbook of Agriculture*. In earlier editions it has been the practice to cover a wide range of aspects relating to the selected topic. Food is no exception and, in fact, it is doubtful if any previous editions have been designed to appeal to such a wide variety of tastes as this 1959 *Handbook*.

In his forward, the US Secretary of Agriculture, Ezra Taft Benson, writes that he hopes this book will be widely read: when it is noted that the contents range from a discussion on the rôle of the peptide linkage in protein formation to recipes for a variety of dishes it seems that there must surely be something for everyone in this publication.

Nutrition and its related studies is the main theme of this book and a number of the early chapters is devoted to the elementary chemistry of the subject and a description of the parts played in nutrition by protein, fats, carbohydrates, amino acids, elements and vitamins. These aspects are discussed in some detail in a clear but not too technical form, and the early chapters lay a sound foundation for the developments which follow.

Needless to say, the nutrient requirements of various types of individuals are covered, taking into consideration age and occupation. This discussion is backed by some useful statistics on the effect of adequate and inadequate nutritional levels on general health.

Food quality is also treated at some length and although most of the standards and label requirements naturally refer to US conditions, it is useful to compare the regulations in that country with those existing elsewhere in the world. Food processing is 'big business' in the USA and without doubt they are world leaders in this particular field. Developments in processing techniques are a major factor in ensuring that foodstuffs, particularly perishables, are presented for sale to the public in the best possible condition as far as nutrient content is concerned. Processing has also been responsible for alleviating to a large extent the losses due to the rapid deterioration of perishable foodstuffs: losses which are costly to all concerned—farmer, merchant and consumer.

In the concluding chapters an endeavour has been made to put food 'in a national and international framework'. To this end a brief review is given of the activities of FAO and its aims, and also a picture of the feeding problem which will confront the world in the next 40 years. Finally, the question of surplus disposal is covered and in particular the steps which the US is taking to reduce its own food surpluses. It is well to be reminded that it is not easy to give food away; furthermore it is an expensive business bearing in mind that donation programmes require distribution systems, and that quite often the recipient has to be educated in the value and use of the donated foods. The answer to the question 'Why don't you [the USA] give away your food surpluses' makes interesting and thought-provoking reading.

This is a large volume with a wealth of detailed information presented by experts in many fields. Few are likely to find all chapters to their liking, so it is of value to find the subject matter grouped in the introduction according to the interests of different readers, be they technologists, teachers, students, farmers or housewives. Of value, too, is the glossary, which in non-technical language defines the semi-scientific terms which are used in the book. P. V. JOYNER.

British Parasitic Fungi. W. C. MOORE. Cambridge. 45s.

The sub-title of this book is *A host-parasite index and a guide to British literature on the fungus diseases of cultivated plants*. The author, who is Director of the Plant Pathology Laboratory, Ministry of Agriculture, Fisheries and Food at Harpenden, has given a very useful guide to the parasitic fungi that have been reported on cultivated plants in Great Britain.

The first part of the book gives an alphabetical list of the scientific and common names of cultivated host plants and their fungal parasites recorded in UK literature. The second part lists the parasites in alphabetical order with references to literature, including the first description and that in Saccardo's *Sylloge Fungorum;* the bibliography on the diseases caused by the parasite on various host plants is also given, as is the distribution in Great Britain. For the more common diseases of important cultivated crops, such as fruits and potatoes, a comprehensive literature review is given on biology, physiological races of the parasites, soil and climatic conditions favouring the spread of the disease, resistant plant varieties and control measures. Some myxomycetes and actinomycetes are included, the book covering most plant parasites except the bacteria and viruses.

The only comparable publication is Ainsworth's *The Plant Diseases of Great Britain*, published in 1937.

With the rapid increase in literature of Plant Pathology, Dr. Moore's book, which covers the literature up to the end of 1958, will be welcomed by many plant pathologists, horticulturalists and others active in the field of plant diseases. One hopes a similar index on bacterial and virus disease will follow soon. J. TH. W. MONTAGNE.

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